SEDR 104

PROJECT MERCURY FAMILIARIZATION MANUAL

NASA

MANNED SATELLITE CAPSULE

CONFIDENTIAL

index only → CN-75133

NASA

X64-80348 #
Code 5C

PROJECT MERCURY FAMILIARIZATION MANUAL:

(NASA CR-55226; SEDR-104)

COPY NO. 158

CLASSIFICATION CHANGE

TO - UNCLASSIFIED

By authority of T.D. No. 11612 Date 3/11/74

Changed by

NASA

MANNED SATELLITE CAPSULE (U)

NOTICE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U. S. C., Section 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

AVAILABLE TO U.S. GOVERNMENT AGENCIES ONLY

5605308

init caps

MCDONNELL AIRCRAFT Corp.,

St. Louis, Mo.

1 NOVEMBER 1961

(Opsa)

CONFIDENTIAL

450p (Orig)

INDEX OF EFFECTIVE PAGES

The pages of this Manual currently in effect are listed below in numerical order.

Page No.	Issue
A	Basic
B	Basic
C	Basic
1-1 thru 1-29	Basic
2-1 thru 2-28	Basic
3-1 thru 3-54	Basic
4-1 thru 4-63	Basic
5-1 thru 5-22	Basic
6-1 thru 6-11	Basic
7-1 thru 7-5	Basic
8-1 thru 8-10	Basic
9-1 thru 9-32	Basic
10-1 thru 10-35	Basic
11-1 thru 11-52	Basic
12-1 thru 12-29	Basic
13-1 thru 13-76	Basic

FOREWORD

The purpose of this document is to present a clear, operational description of the various capsule systems and major components. Two types of usage for the manual are visualized. The first is an orientation-indoctrination type document. The second use is as a reference document containing relatively detailed information on all systems and components.

The manual is divided by capsule systems. The first part of each section is devoted to the description and operation of "specification compliance capsule" system. Capsules numbered 18 and 19 are the specification compliance capsule. They are manned orbital capsules and are representative of the Mercury Program. Immediately following the specification compliance system coverage is the Test Configuration Capsule Coverage. This area compares the other capsules to the specification compliance capsule or to a prior capsule. The capsules are compared on a, "like specification compliance capsule except as follows" bases. The Test Configuration Capsules are compared to the specification compliance capsule system or to any other preceding capsule depending on which reference causes the least duplication. The reader will not be required to refer to more than two prior capsules systems including the specification system. Separate information is provided for each capsule test configuration, when the information is the same for each capsule it will not be repeated. All capsules will be covered in this manual for one revision after the particular capsule has been launched successfully. After that date they will be dropped from future issues.

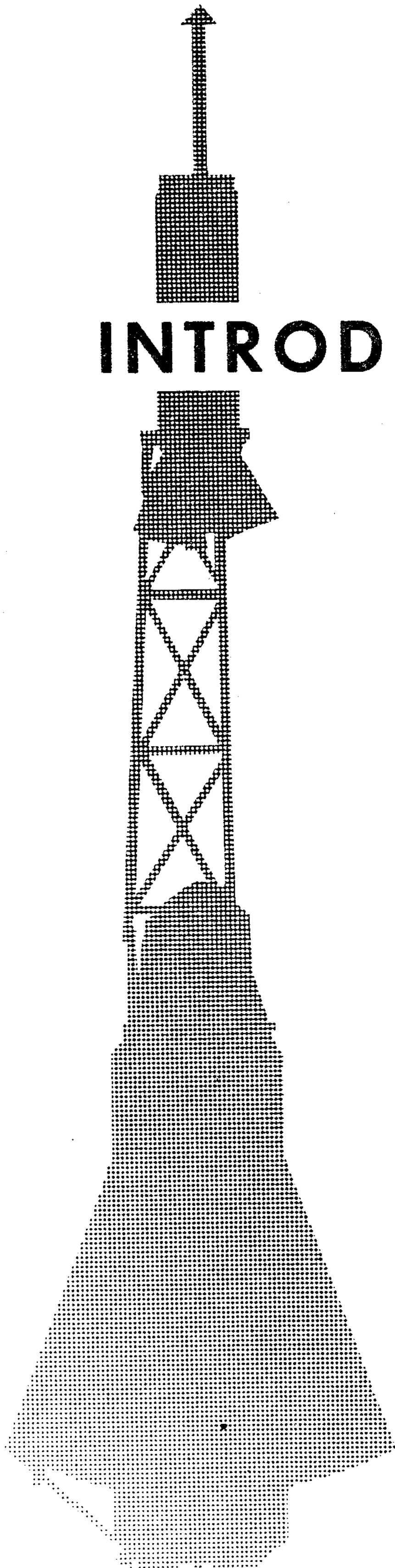
Capsules numbered 2, 3, 4, 5, 6, 7, 11 and 14 are covered in the 1 February 1961 issue of SEDR 104 revised 1 August 1961. Capsules numbered 12, 15, 17 and 20 have been assigned an eighteen orbit mission and will be covered in a latter publication.

All capsule configurations are not finalized as of this printing, additional information will appear in subsequent revisions to this document, reflecting changes as they are incorporated in the capsule.

SECTION INDEX

PAGE

SECTION I



INTRODUCTION

TABLE OF CONTENTS

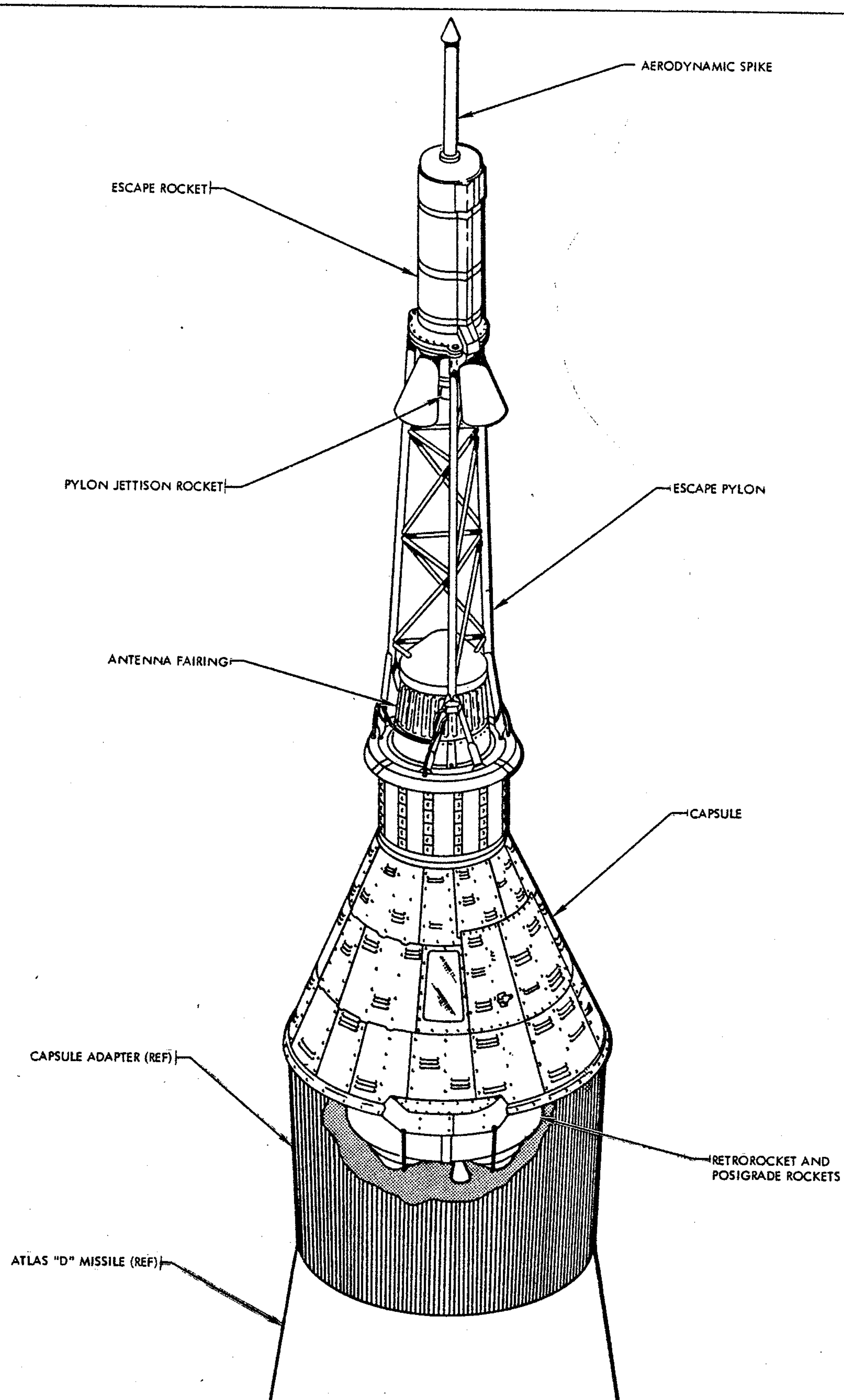


FIGURE 1-1 CAPSULE PRELAUNCH CONFIGURATION

PM45-2C

I. INTRODUCTION TO PROJECT MERCURY

1-1. MISSION DESCRIPTION

The possibility of man venturing into space has shifted quite recently from the fantasy of "science fiction" to the realm of actuality. Scientific progress has slowly but surely loosened man's ties to the earth, and recent technological advances have promised to release him completely. Today, space flight is considered well within the range of man's capabilities.

Initiated by the National Aeronautics and Space Administration, a space flight program is now underway. Through the research, design and production facilities of McDonnell Aircraft Corporation and their many sub-contractors, an American will venture into space. The program that will put him there is Project Mercury.

Fundamentally, the mission of Project Mercury is the projection of a manned capsule into a semi-permanent orbit about the earth, the study of man's capabilities in space flight, and the subsequent safe return of the capsule and its occupant to the earth's surface. It is immediately obvious that the mission, while simply stated, is of tremendous scope and magnitude, and requires exceptional coordination of manpower and facilities. The date contained in this and succeeding sections will provide detailed information on the equipment and procedures utilized to accomplish that mission.

1-2. CAPSULE DESCRIPTION

1-3. General

See Figures 1-1, 1-2, 1-3 and 1-4. The Project Mercury capsule is basically a conical structure containing a pressurized area suitable for human occupation during launch, orbit, and recovery phases of the mission. The "base" of the cone contains provisions for attachment to the ATLAS booster,

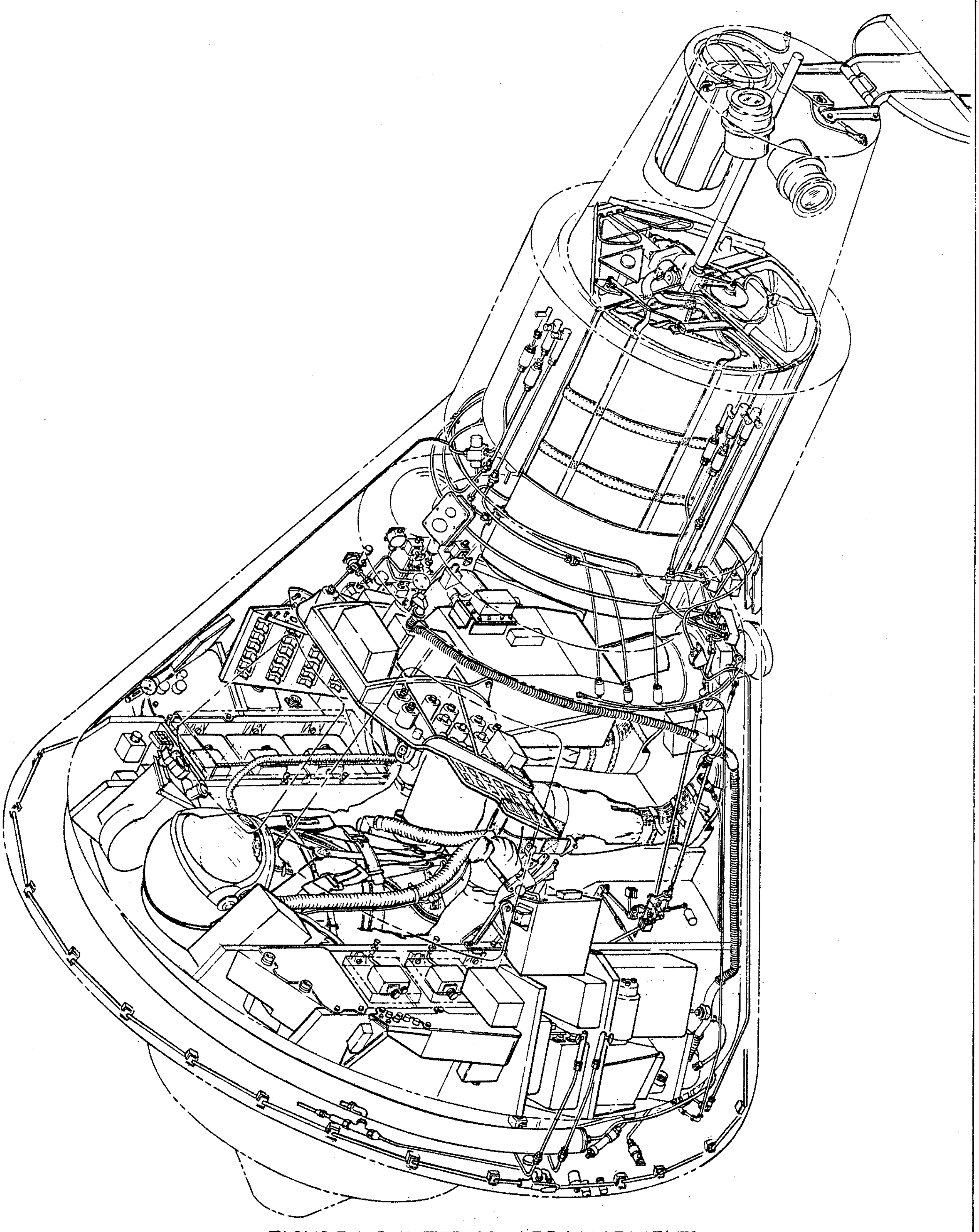


FIGURE 1-2 INTERIOR ARRANGEMENT

PM45-1A

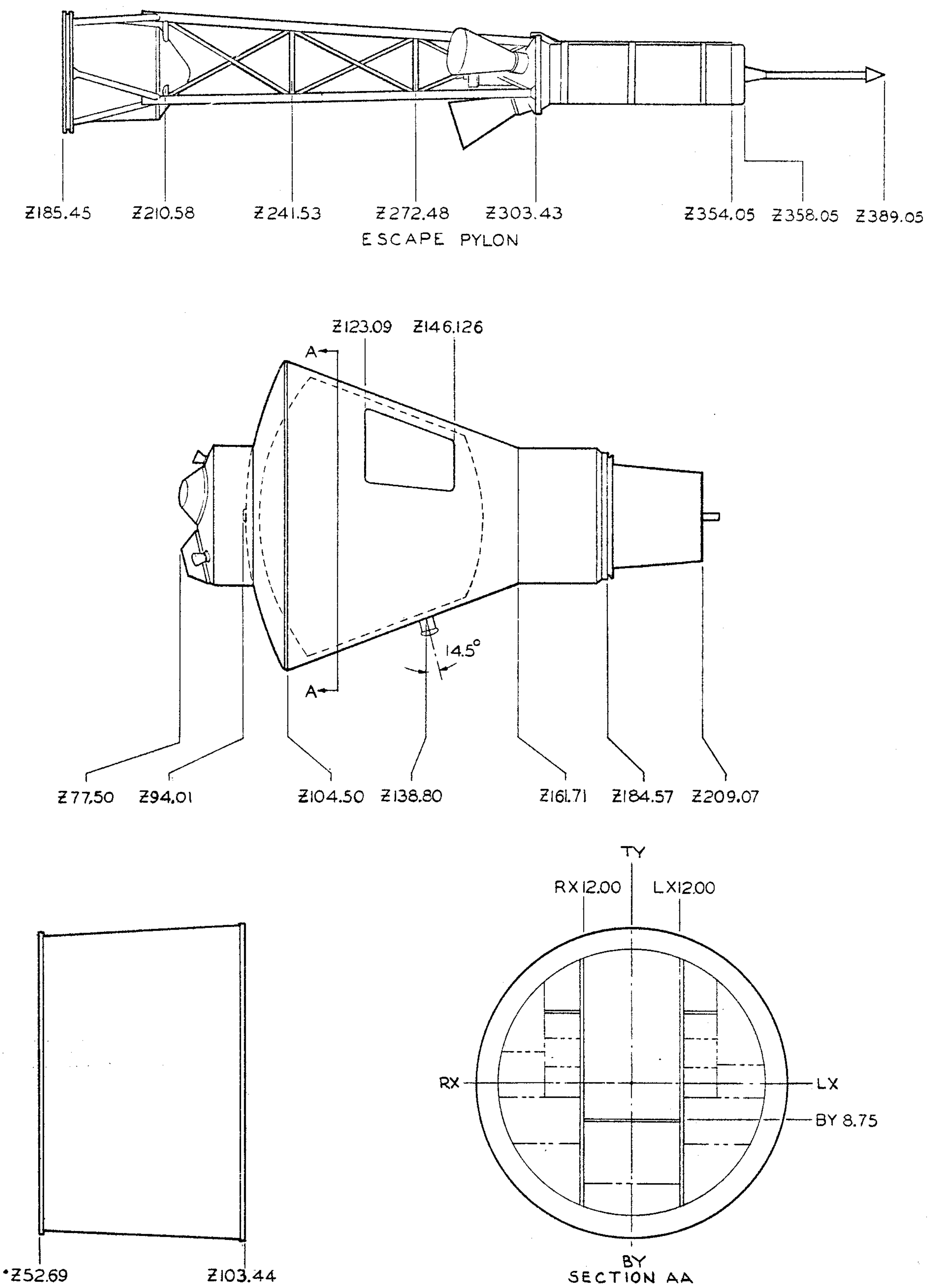


FIGURE 1-3 STATIONS DIAGRAM

PM45-12B

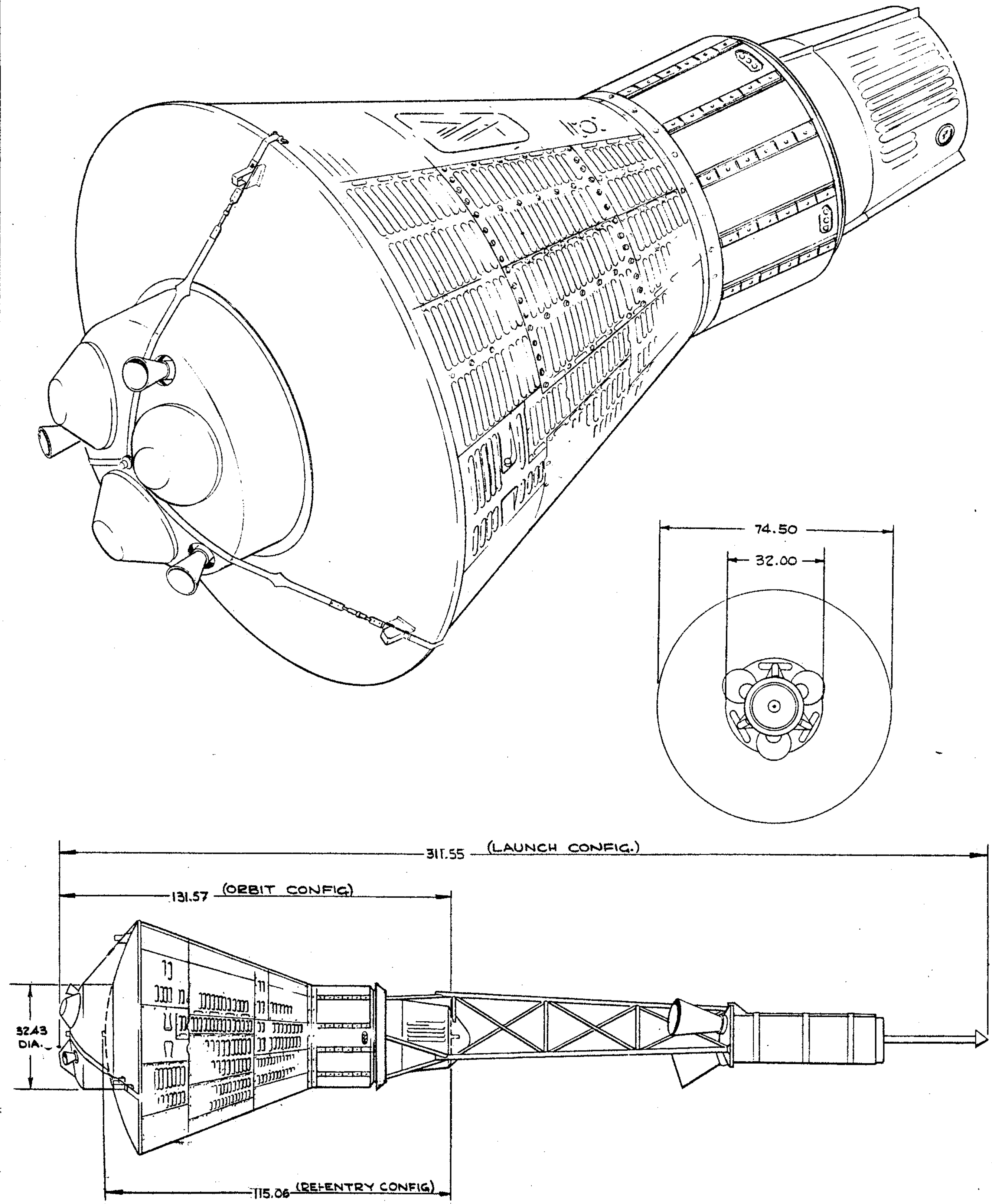
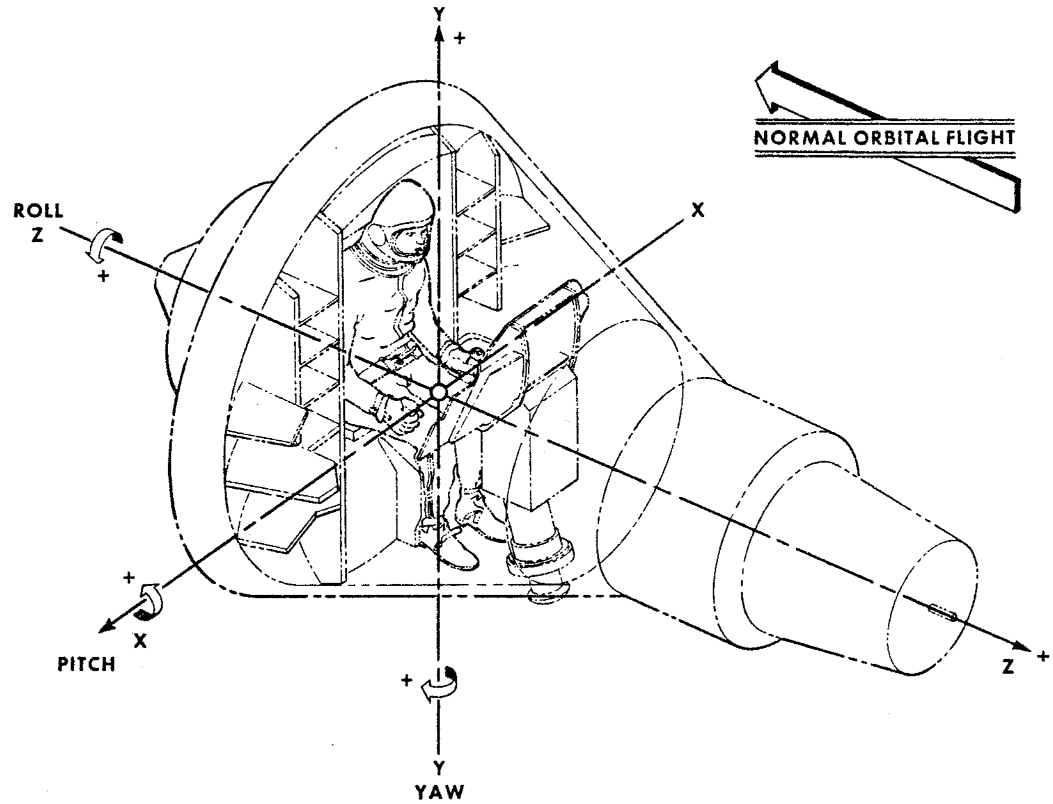


FIGURE 1-4 CAPSULE DIMENSIONS

PM45-15B



PITCH

PITCH IS DEFINED AS THE ROTATION OF THE CAPSULE ABOUT ITS X-AXIS THE PITCH ANGLE IS ZERO DEGREES (0°) WHEN THE Z-AXIS LIES IN A HORIZONTAL PLANE. USING THE ASTRONAUTS RIGHT SIDE AS A REFERENCE, POSITIVE PITCH IS ACHIEVED BY COUNTERCLOCKWISE ROTATION FROM THE ZERO DEGREE (0°) PLANE. THE RATE OF THIS ROTATION IS THE CAPSULE PITCH RATE AND IS POSITIVE IN THE DIRECTION SHOWN AS ARE THE CONTROL MOVEMENTS WHICH CAUSE IT. THE CONTROL HANDLE MOVES TOWARD THE ASTRONAUT AND THE POSITIVE + PITCH REACTION JET FIRES.

YAW

YAW IS DEFINED AS ROTATION OF THE CAPSULE ABOUT ITS Y-AXIS. CLOCKWISE ROTATION OF THE CAPSULE, WHEN VIEWED FROM ABOVE THE ASTRONAUT, IS CALLED RIGHT YAW AND IS DEFINED AS POSITIVE (+).
THIS MOVEMENT IS PRODUCED BY POSITIVE CONTROL MOTION. THE CONTROL HANDLE IS ROTATED CLOCKWISE (AS VIEWED FROM ABOVE THE ASTRONAUT) AND THE POSITIVE (+) YAW REACTION JET FIRES. YAW ANGLE IS CONSIDERED ZERO DEGREES (0°) WHEN THE CAPSULE IS IN NORMAL ORBITAL POSITION (BLUNT END OF CAPSULE FACING LINE OF FLIGHT). WHEN THE POSITIVE Z-AXIS OF THE CAPSULE IS DIRECTED ALONG THE ORBITAL FLIGHT PATH (RECOVERY END OF CAPSULE FACING LINE OF FLIGHT), THE YAW ANGLE IS 180°.

ROLL

ROLL IS DEFINED AS THE ROTATION OF THE CAPSULE ABOUT ITS Z-AXIS. CLOCKWISE ROTATION OF THE CAPSULE, AS VIEWED FROM BEHIND THE ASTRONAUT, IS CALLED RIGHT ROLL AND IS DEFINED AS POSITIVE (+). THIS MOVEMENT IS INITIATED BY MOVING THE CONTROL HANDLE TO THE RIGHT THEREBY FIRING THE POSITIVE (+) ROLL REACTION JET. WHEN THE X-AXIS OF THE CAPSULE LIES IN A HORIZONTAL PLANE, THE ROLL ANGLE IS ZERO DEGREES (0°).

ACCELEROMETER POLARITY WITH RESPECT TO GRAVITY

WITH THE CAPSULE IN THE LAUNCH POSITION THE Z-AXIS WILL BE PERPINDICULAR TO THE EARTH'S SURFACE AND THE Z-AXIS ACCELEROMETER WILL READ +1 "G".

WITH THE CAPSULE IN AN ATTITUDE SUCH THAT THE Z AND X-AXIS ARE PARALLEL TO THE EARTH'S SURFACE AND THE ASTRONAUT IS IN A HEAD UP POSITION, THE Y-AXIS ACCELEROMETER WILL READ +1 "G".

WITH THE Z AND Y-AXIS IN A PLANE PARALLEL TO THE EARTH'S SURFACE AND WITH THE RIGHT SIDE OF THE ASTRONAUT UP, THE X-AXIS ACCELEROMETER WILL READ +1 "G".

FIGURE 1-5 CAPSULE POLARITY ORIENTATION WITH RESPECT TO ASTRONAUT

PM45-233

through use of special adapters. The "apex" of the cone contains the devices for recovering the capsule at the conclusion of a mission, and equipment which would allow the astronaut to escape in the event of an emergency during the launch phase. Provided in the capsule proper are systems which regulate environment, flight attitude, data recording and telemetering, and capsule recovery.

When in place on the nose of the booster, the small end of the capsule is up. The Astronaut is on his back in a sitting position. During launch and acceleration phase, the Astronaut faces forward with respect to capsule flight path. When the booster-capsule combination reaches a specific altitude, attitude and velocity, they separate. The booster slows, and returns to the earth's atmosphere where it is destroyed. The capsule is stablized momentarily, then rotated 180° about its yaw axis. Throughout the remainder of the flight, whether orbital or ballistic, the Astronaut faces aft with respect to capsule flight path.

1-4. <u>Cabin</u>

1-5. Arrangement

The equipment within the capsule cabin interior, Figure 1-6, is arranged so that all operating controls and emergency provisions are accessible to the Astronaut when in the normal restrained position. Cabin equipment basically consists of an Astronaut's support couch, a restraint system, instrument and display panels, navigational aids, flight and abort control handles, food and water supply, waste container, survival kit, cameras, and electronic equipment required to operate communication system.

1-6. Support Couch

The Astronaut support couch (Figure 1-7) is designed to firmly support the Astronaut's body during the capsule launch, re-entry and landing phases.

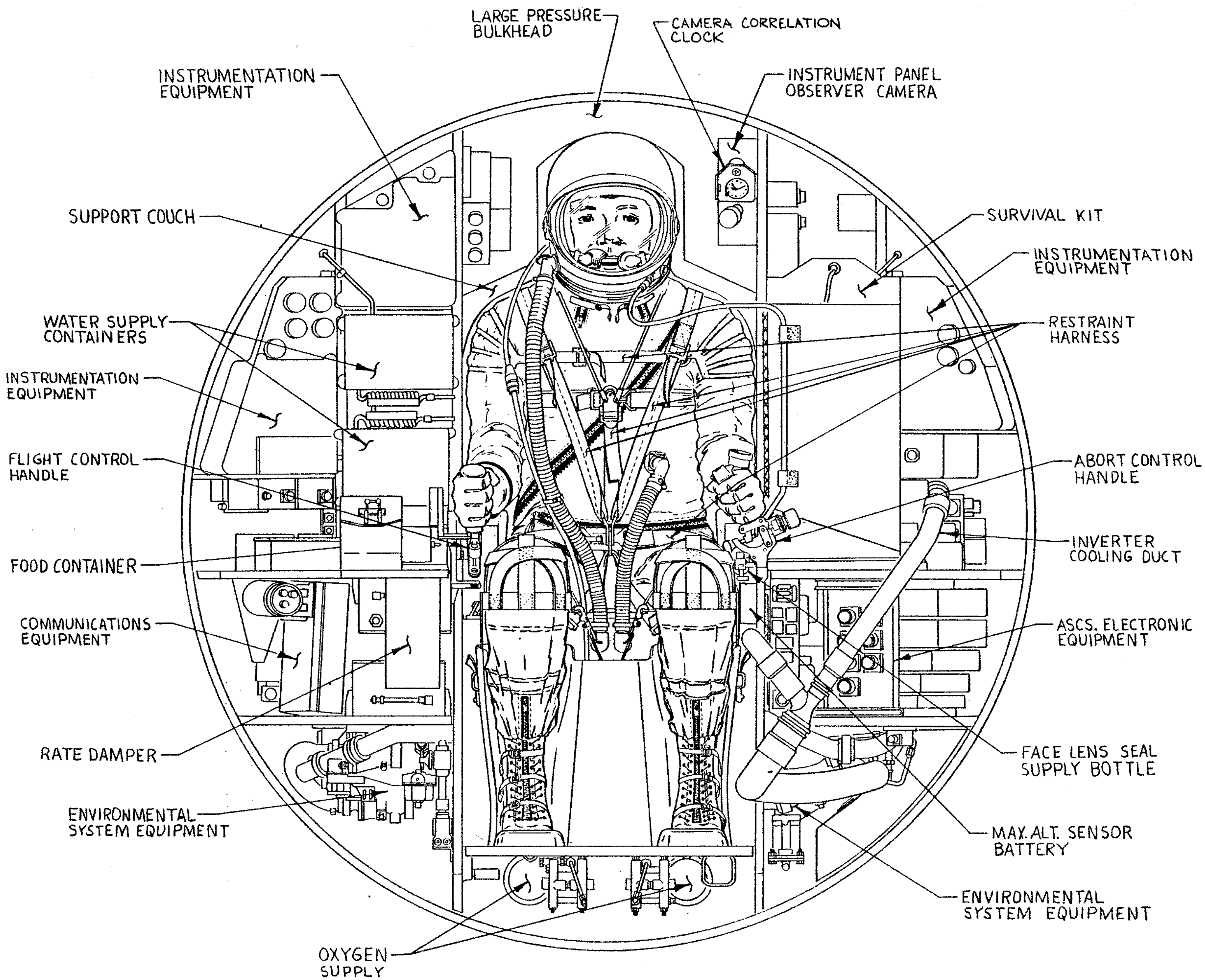


FIGURE 1-6 CABIN EQUIPMENT (SHEET 1 OF 2)

PM45-19B-1

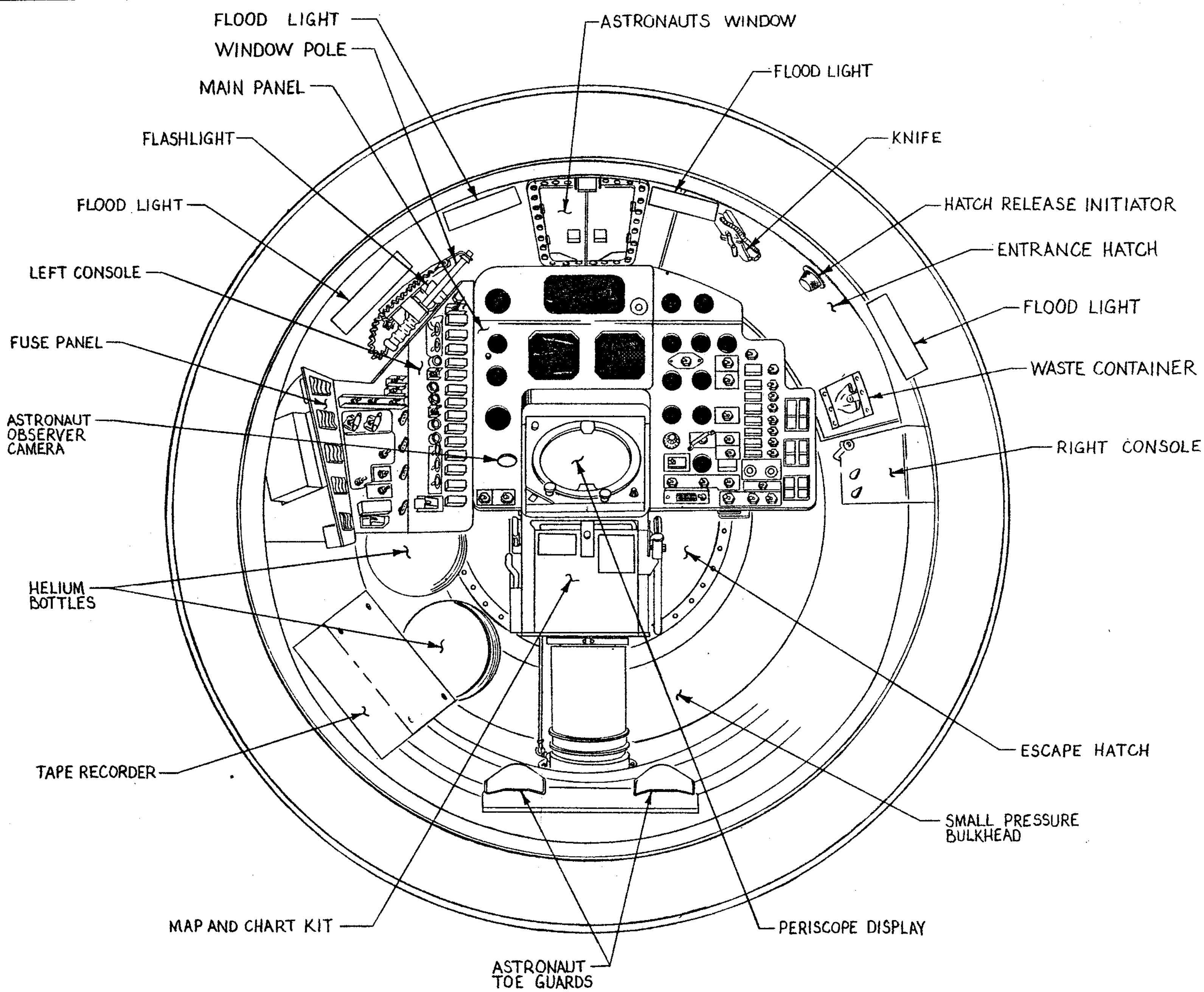


FIGURE 1-6 CABIN EQUIPMENT (SHEET 2 OF 2)

PM 45-19B-2

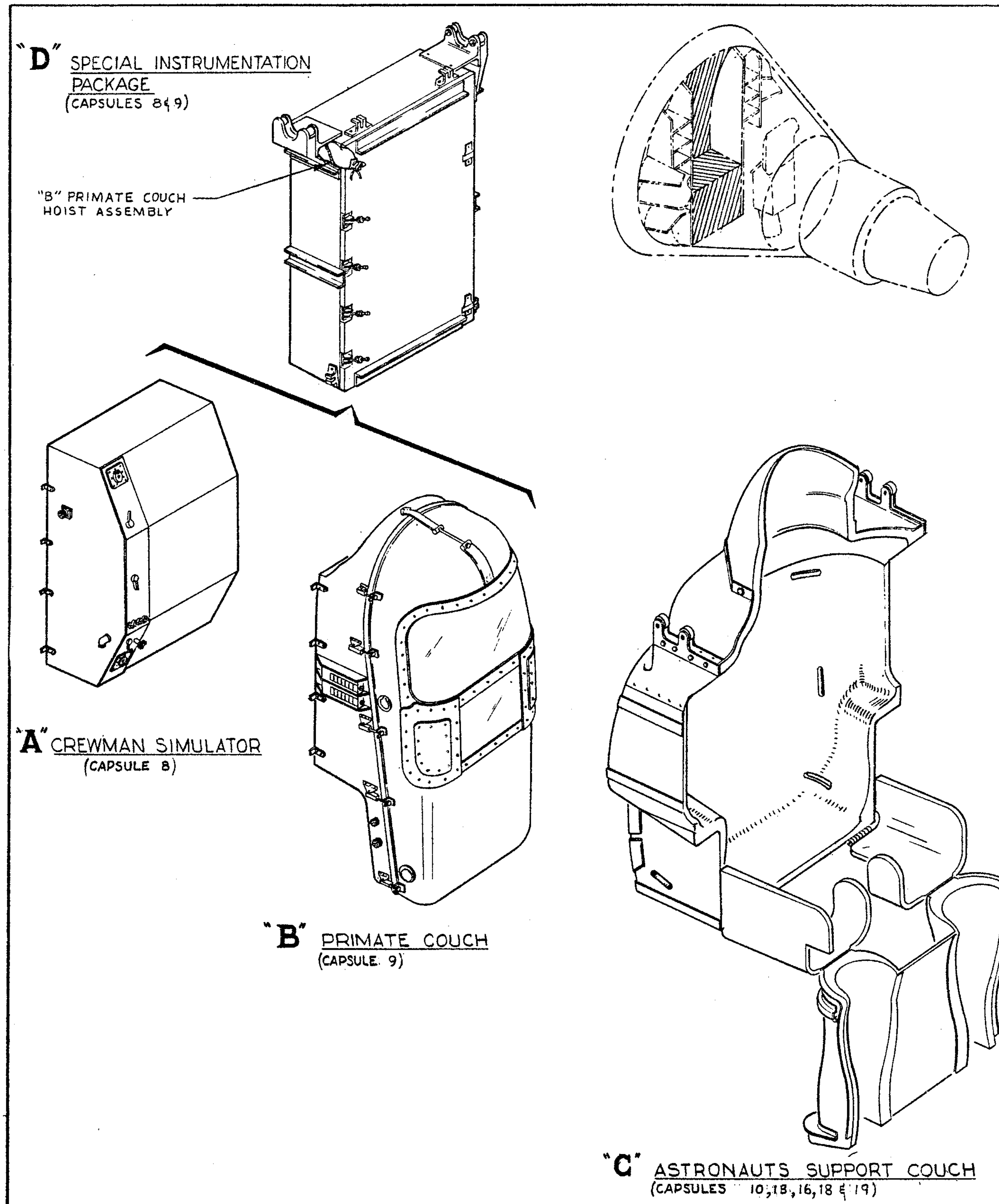


FIGURE 1-7 BASIC MISSION EQUIPMENT

PM45-1350

The support couch also protects the Astronaut from loss of consciousness during capsule peak acceleration and from possible injury at capsule impact. The support couch is centrally located adjacent to the large pressure bulkhead. The couch is constructed of a crushable, honeycomb material, bonded to a Fiberglass shell, and lined with a comfort liner. The support couch is molded to the contour of a specific Astronaut's body to provide maximum body support during capsule flight. The couch is fabricated in sections to enable couch installation through the capsule entrance hatch.

1-7. Restraint System

The Astronaut's restrain system (See Figure 1-8) is designed to firmly restrain the Astronaut in the support couch during capsule maximum deceleration. The restrain system consists of shoulder and chest straps, leg straps, a crotch strap, a lap belt, and toe guards. The shoulder straps may be adjusted to restrain or release the Astronaut, by a harness reel control handle, located forward of the upper left side of the support couch. The lap belt and crotch strap firmly support the Astronaut's lower torso, and the chest strap and shoulder straps restrains the Astronaut's upper torso. The leg straps and toe guards firmly restrain the Astronaut's legs and feet. The Astronaut's hands and arms are restrained by gripping the abort and flight control handles, located near the ends of the support couch arm rests.

1-8. Instrument Panels (See Figures 1-9 And 1-10)

The capsule instruments and controls are located on a main instrument panel, a left console, and a right console. The main instrument panel is located directly in front of the Astronaut's support couch, as viewed by the Astronaut, and is attached to the periscope housing. The main panel is designed so that the periscope display scope forms the lower control section of the instrument

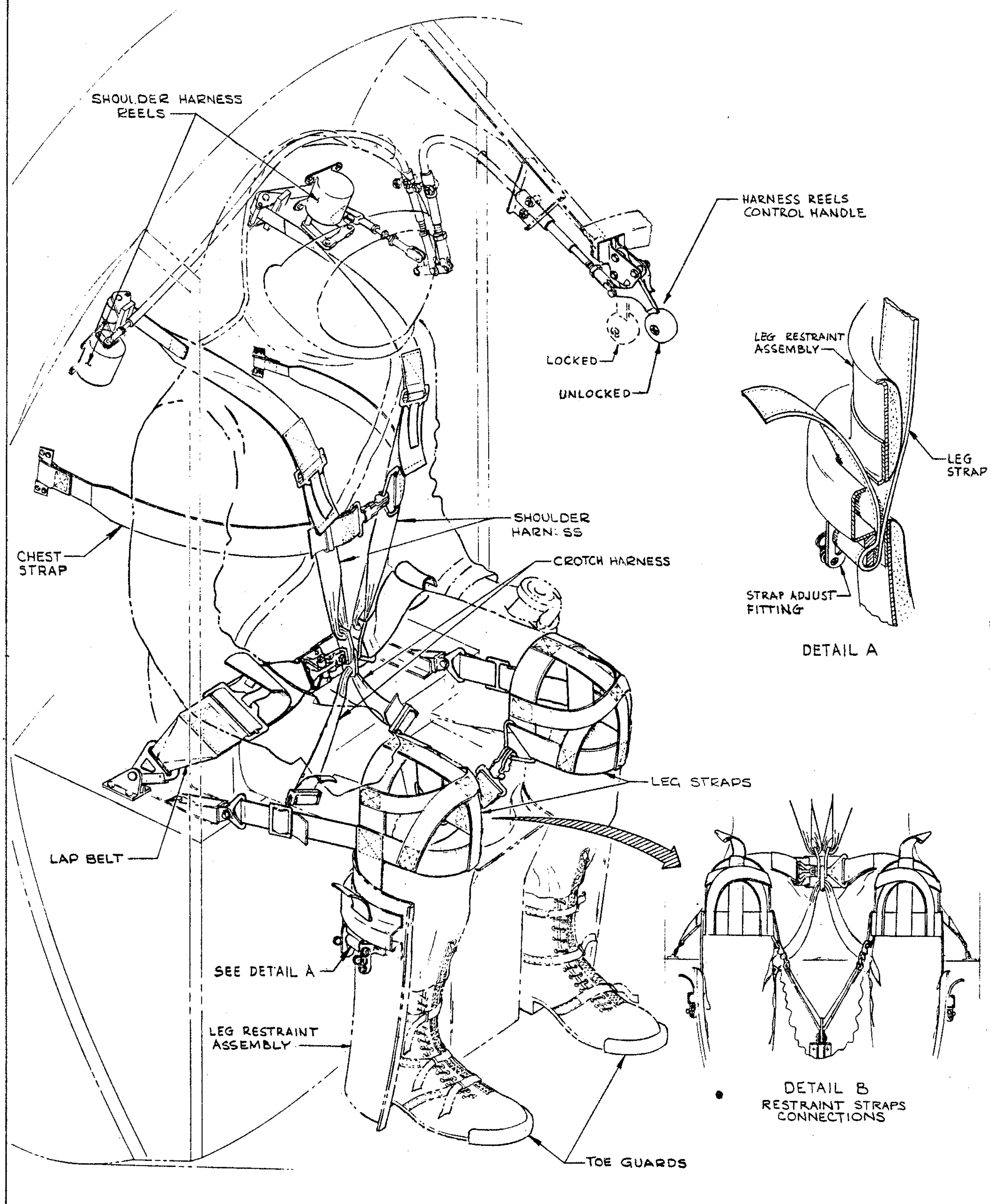


FIGURE 1-8 ASTRONAUTS RESTRAINT SYSTEM (CAPSULES 10, 13, 16, 18 & 19) PM45-21D

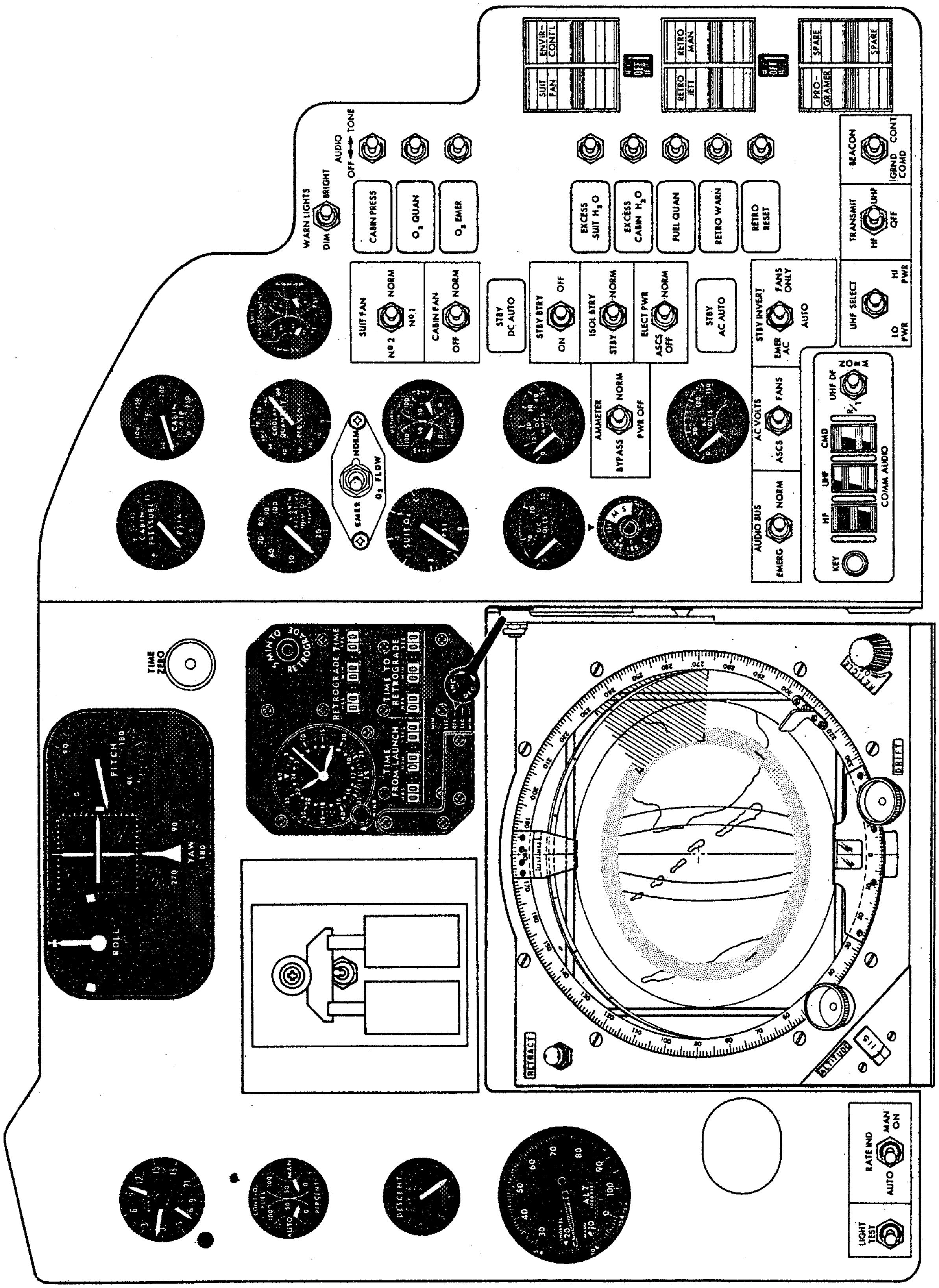


FIGURE 1-9 MAIN INSTRUMENT PANEL (CAPSULE 9) (SHEET 1 OF 2)

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

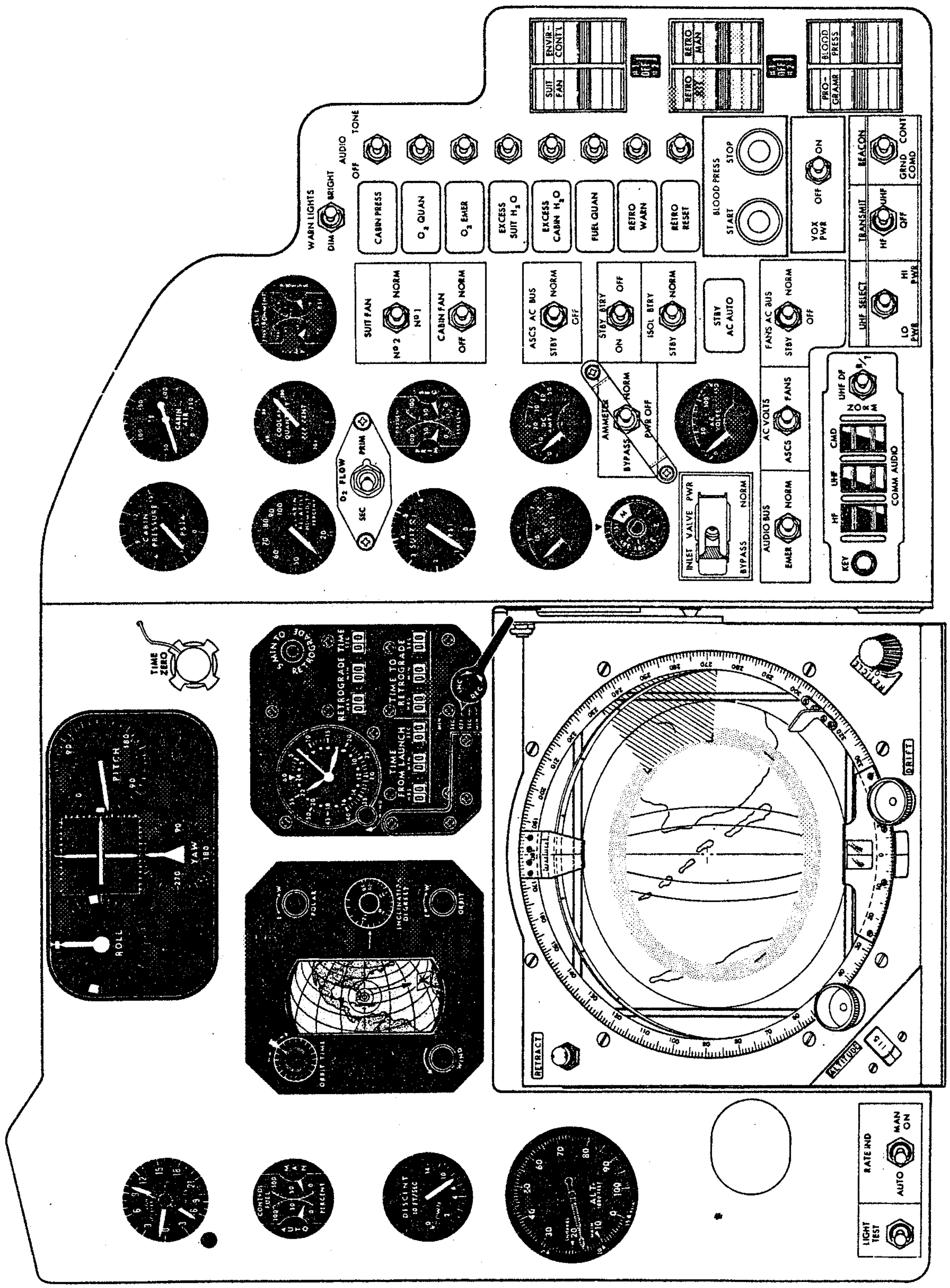
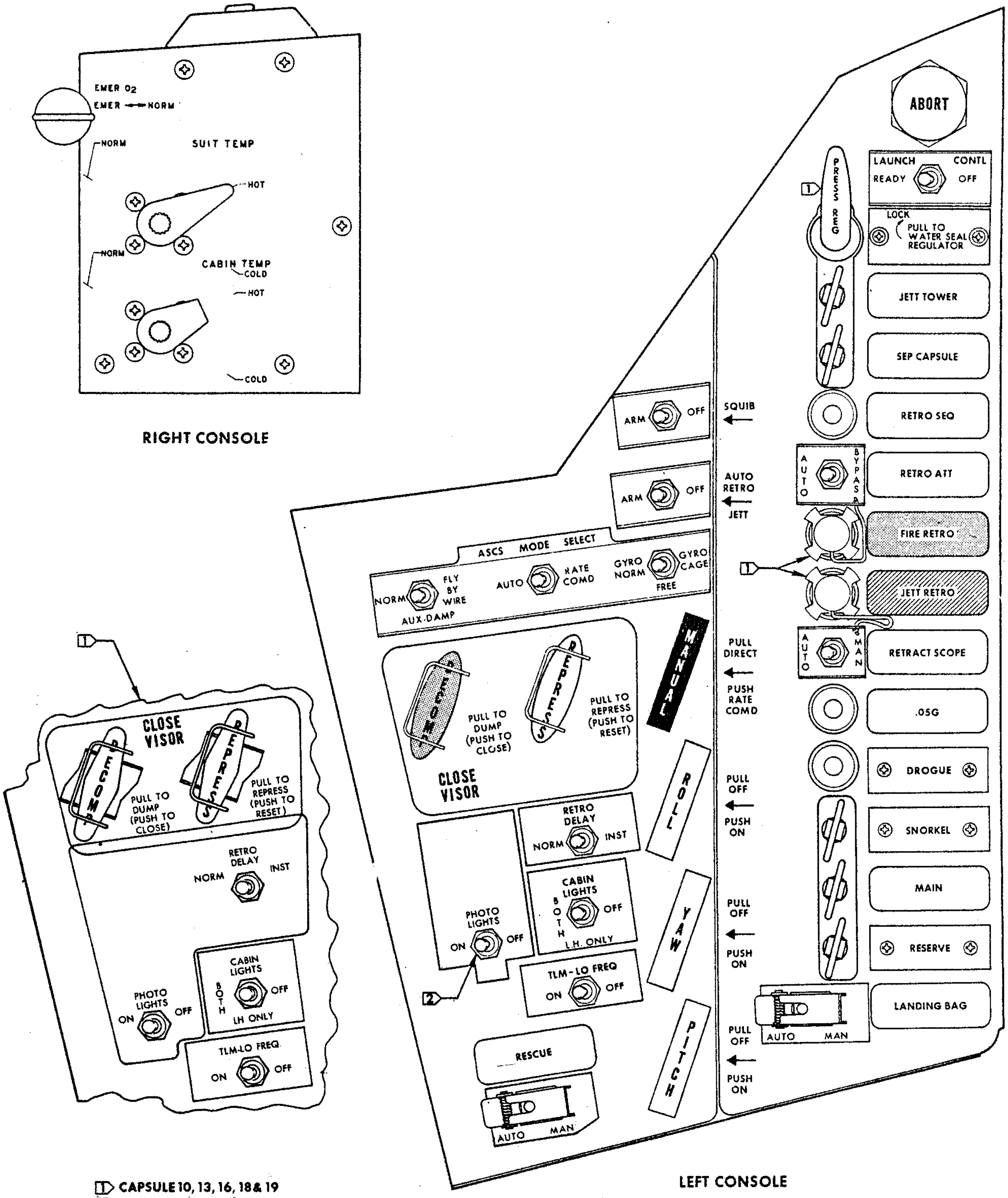


FIGURE 1-9 MAIN INSTRUMENT PANEL (CAPSULE 10, 13, 16, 18 & 19) (SHEET 2 OF 2)



1 CAPSULE 10, 13, 16, 18 & 19
2 CAPSULE 13 ONLY

FIGURE 1-10 RIGHT AND LEFT CONSOLE (CAPSULE 9 10,13,16,18 & 19)

PM45-161 B

panel. Navigational instruments are located in the left and center sections of the main panel. Environmental system indicators and controls are located in the right upper section of the main panel. Electrical switches, indicators and communication system controls are located in the lower right section of the main panel. The left hand console is located on the left side of the main panel and is arranged to provide accessibility and visibility to the Astronaut when in the fully restrained position. The console includes a telelight sequence and warning panel, and indicators and controls for the capsule automatic stabilization control system, environmental control and landing system. The right hand console, located below the capsule entrance hatch, includes controls for the environmental control system. A window pole, located adjacent and to the left of observation window, enables the Astronaut to actuate controls in the fully pressurized suit.

1-9. Navigational Aids

The capsule is equipped with navigational aids and instruments to enable the Astronaut to compute factors relative to his flight or landing. The navigational aids consist of the periscope, satellite clock, earth path indicator, altimeter, angular rate indicator and the map case. All navigational aids are located directly in front of the Astronaut, on or adjacent to the main instrument panel.

1-10. Controls

Capsule controls are located forward of each arm rest of the support couch. An emergency escape handle is located forward of the support couch left arm rest. The escape handle is utilized to initiate the abort sequence. To prevent inadvertent actuation of the escape system, the escape handle is provided with a manual lock. The manual control handle, located forward of the support couch right arm rest, is utilized to control flight attitude of the capsule in the event the automatic system failed. This handle is also normally locked.

1-11. Food, Water and Waste Storage

All manned capsules will be provided with food and water sufficient for the particular mission. (See Figure 1-6). The food will provide approximately 3,000 calories. The 6 pound water supply is contained in two flat bottles, each fitted with an extendable tube. A waste container is located on the interior of the entrance hatch.

1-12. Survival Equipment

The survival kit (See Figure 1-11), stowed at the left side of the couch, contains the following:

1 Life Raft	1 Signal Mirror
1 Desalting Kit (for 8 pts.)	1 Ultra SARAH Rescue Beacon
2 Shark Repellant Packages	1 Survival Ration
3 Dye Markers	1 Container of Matches
1 Tube Zinc Oxide	1 Whistle
1 First Aid Kit	1 Nylon Cord (10 ft.)
1 Bar Soap	1 Signal Light
3 Morphine and Anti-Seasickness Injectors	1 Pocket Knife

A knife, installed in a case, is located on the entrance hatch interior. (See Figure 1-6). A flashlight is located adjacent and to the left of the observation window.

1-13. Cameras

One 16 mm. camera is mounted in the lower left corner of the main instrument panel for viewing the Astronaut's head and shoulders. A second 16 mm. camera is positioned above and to the left of the Astronaut's couch to record instrument panel readings. These cameras operate continuously during launch and descent, and at programmed intervals during orbit.

1-14. BOOSTER DESCRIPTION

The launch vehicle, or booster, used to project the Project Mercury capsule into orbit is the ATLAS "D" missile. Capsule adapters replace the nose cones of the missiles. The capsule "base" is then attached to the adapter with a segmented clamp ring. At the proper time, explosive bolts in the clamp ring are fired, releasing the capsule. The adapter remains with the booster.

1-15. CAPSULE RECOVERY

A normal mission is intended to terminate with the capsule landing in a predetermined area of the ocean. Under normal circumstances, ships and helicopters will be standing by with provisions to pick up the buoyant capsule immediately after landing. Considering the possibility that the capsule could land in other than the intended area; numerous devices, both electronic and visual, are automatically energized or deployed at the time of landing to aid in locating the capsule. Depending upon the weather, possible capsule damage and the Astronaut's physical condition, etc., he may either stay in the capsule, or take to the life raft which is provided as part of the survival equipment.

1-16. CREW

1-17. Requirements

The capsule crew consists of one man representing the peak of physical and mental acuity, training and mission indoctrination. Much more will be required of the crewman than is normally required of the modern aircraft test pilot. The crewman must not only observe, control and comment upon the capsule system, but must scientifically observe and comment upon his own reaction while in a new, strange environment.

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

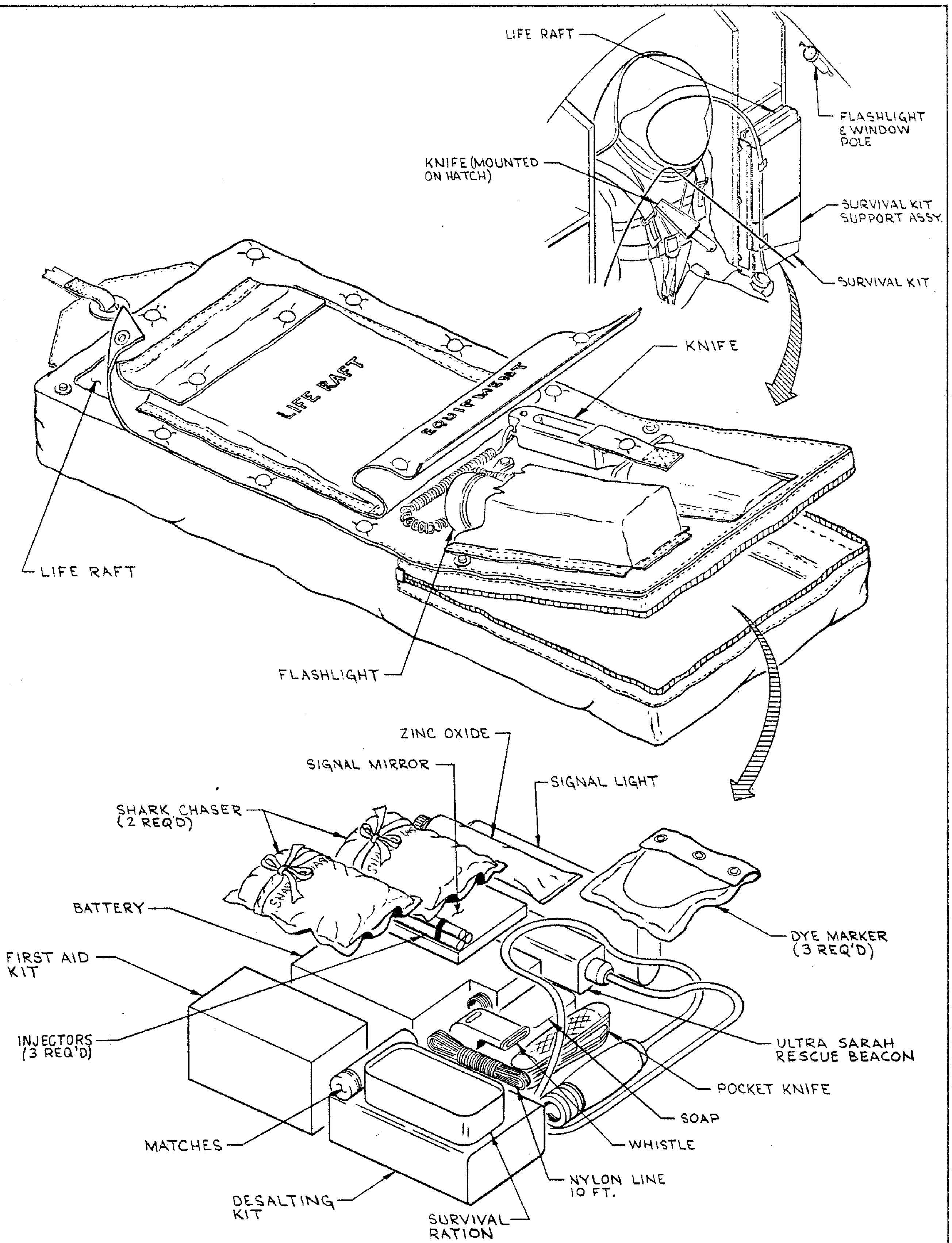


FIGURE 1-11 SURVIVAL KIT

PM45-258

1-18. Selection

From the large number of men who volunteered for Project Mercury, a relatively small group has been selected. Each man in the group has undergone extensive testing and examination which has proven conclusively that he possesses the intelligence, stamina and mental stability required for a project of this type.

1-19. Training

An extensive training program is being conducted for the Astronauts and other designated personnel associated with Project Mercury. The program will provide detailed descriptions and operation of all capsule components in such a manner that the trainee will fully understand the function of each component and the reasons for selecting a particular design. Supplementary briefings will be held so that current design decisions can be made known. Initial training will be of the "group discussion" type, progressing to procedural trainers. Training aids and equipment will be designed to train the Astronauts to achieve the highest attainable degree of proficiency in all normal and emergency procedures. The following objectives will be sought:

a. The Astronaut will be indoctrinated in the general purpose and plans of the space program.

b. He must be completely familiar with all normal and emergency procedures. Emphasis will be placed on this point, so that normal procedures are performed almost automatically.

c. He must be indoctrinated as far as possible in the environmental and physiological aspects of the mission.

d. Since the Astronaut himself has the highest utility value and is the most flexible component in the capsule, he must be able to handle the normal work load in the capsule and still function as an efficient scientific observer.

The completion of an adequate training program will assure a far higher level of reliability with respect to crew function, and of course, increase the probability of a successful mission.

1-20. Physiological Preparation

To minimize the possibility of the Astronaut having to pass body waste solids for the duration of a mission, strict dietary control will be maintained for a considerable period prior to flight. This will allow a nutritional and physical buildup in anticipation of the stringent demands which will be placed upon the Astronaut's physical and mental facilities, and at the same time, control the type of solid waste which will remain in the digestive and elimination systems. Finally, low residue or non-residue type food will be supplied for the Astronaut's consumption during flight.

1-21. Aeromedical Instrumentation

It is extremely important that certain bio-physical functions be measured and recorded during all phases of the mission. Such measurements will assist in monitoring the Astronaut's mental acuity and physical fittness, and will contribute significantly to aeromedical research. The blood pressure microphone, respiration rate and volume, temperature tranducers and the EKG pickups are used to register the Astronaut's physical reactions. Leads are routed from the Astronaut's body to terminals which extend through the suit. Capsule wiring will attach to the suit at these points. The instrumentation will be accomplished in laboratory facilities at the launching site prior to donning the pressure suit. The data thus derived is supplied intermittently to the capsule tape recorder and continuously to the telemetry equipment.

1-22. Astronaut's Apparel

The Astronaut's apparel will consist of a completely enveloping pressurized suit with helmet, suitable undergarments, and boots. The helmet face plate can be opened while the capsule interior is pressurized although normal procedure will be to keep the face plate closed. Each Astronaut is specially fitted and trained in the use of his suit. Oxygen, regulated as to temperature, pressure and humidity, is supplied to the suit for breathing and ventilation. For Astronaut comfort, ventilating air should be supplied to the suit at all times.

1-23. TEST CONFIGURATION CAPSULES

The data contained in paragraphs 1-1 through 1-22 pertains to the Specification Compliance Capsules. Deviations from this data, as applicable to the TEST CONFIGURATION CAPSULES, is explained in paragraphs 1-24 through 1-39. If no reference is made to a particular system or item it is the same as the Specification Compliance Capsule.

1-24. TEST CONFIGURATION NO. 8 CAPSULE

Capsule No. 8 is similar to the specification capsule except in the following areas. Refer to Section II for structural differences.

1-25. Mission Description

The flight objectives of Capsule No. 8 combined with an Atlas missile, will be a single eliptical orbit around the earth, with Re-entry initiated at a preset point on the orbital trajectory. Capsule No. 8 will not be manned, but will be equipped with a crewman simulator to artifically contaminate the capsule environmental system to a degree, similar to that which would be experienced by an Astronaut during an extended flight. This flight will qualify the following systems:

McDONNELL *Aircraft Corporation*
ST. LOUIS, MISSOURI
~~CONFIDENTIAL~~

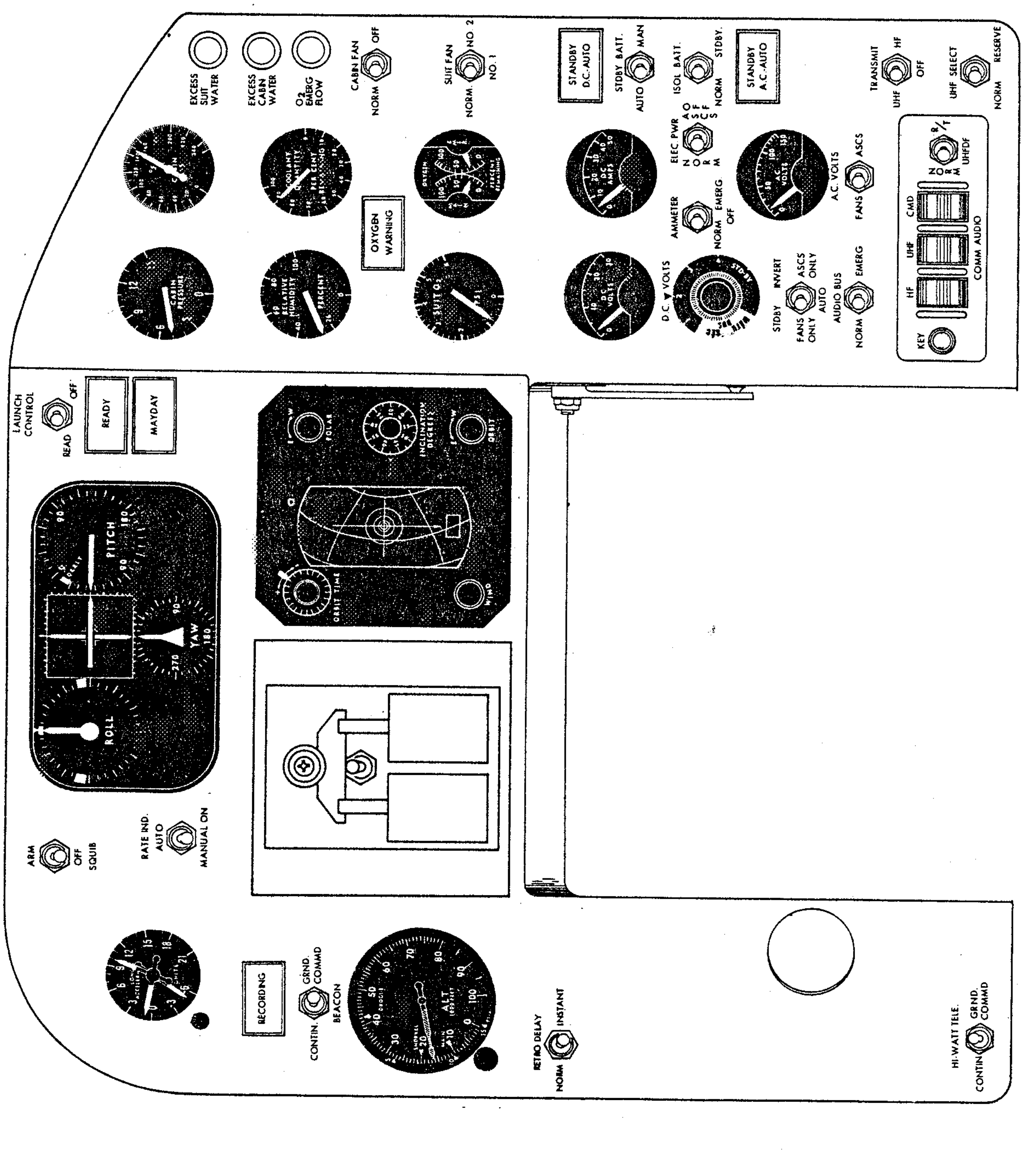
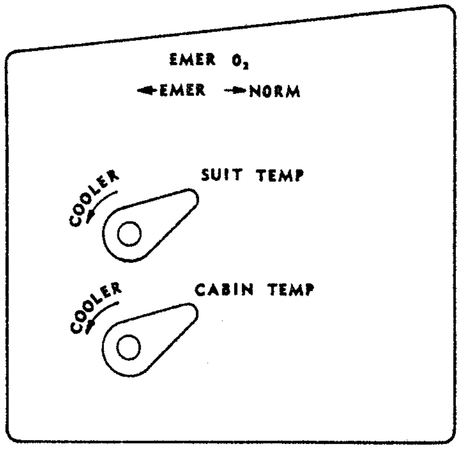
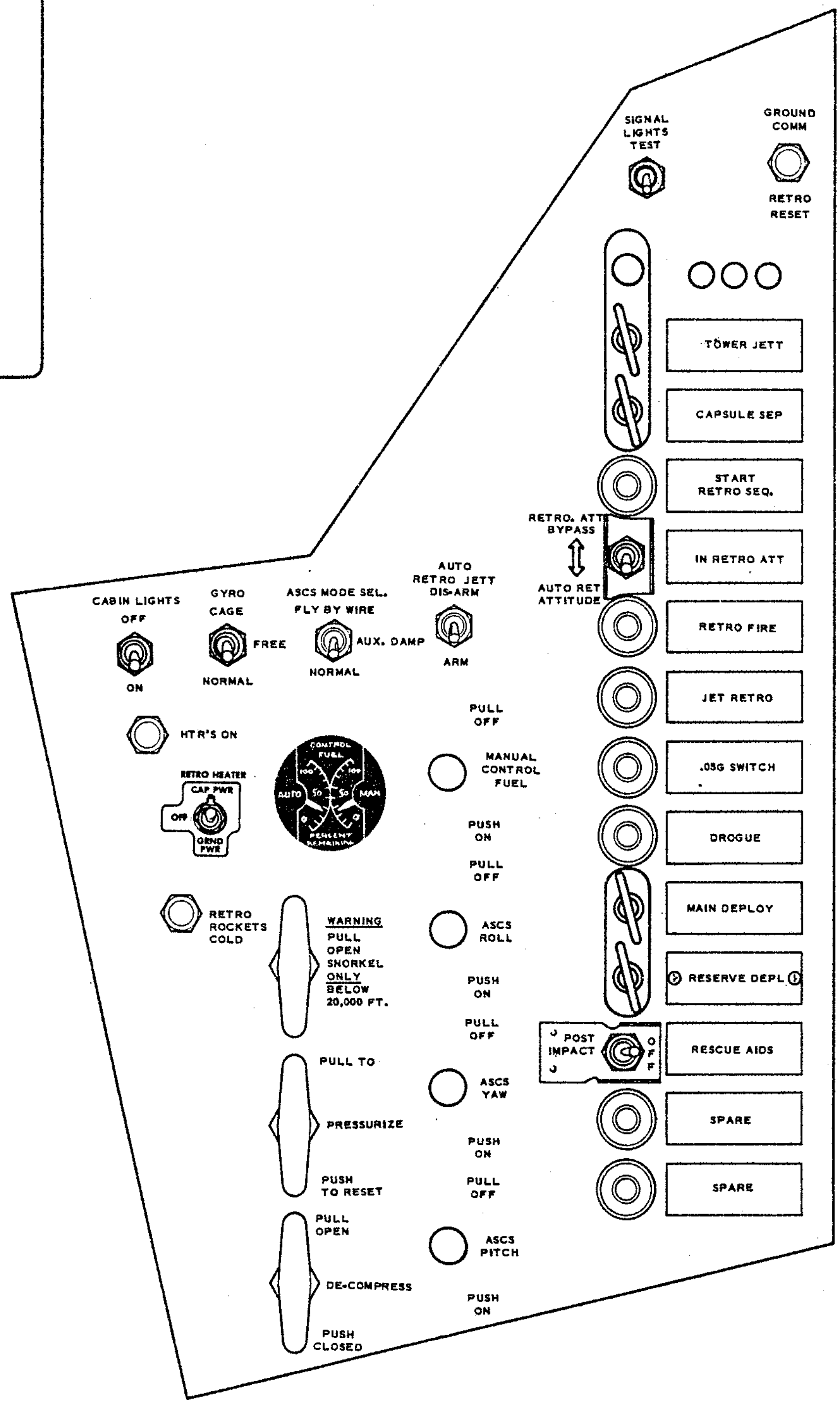


FIGURE 1-12 MAIN INSTRUMENT PANEL (CAPSULE 8)

PM45-119C



RIGHT CONSOLE



LEFT CONSOLE

FIGURE 1-13 RIGHT AND LEFT CONSOLES (CAPSULES 8)

PM45-120B

a. Capsule-booster separation.

b. Capsule and escape systems.

c. Environmental control system.

d. Automatic stabilization system.

e. Landing re-entry and recovery system.

f. Posigrade and Retrograde rockets systems.

g. Instrumentation and telemetry systems.

In addition the following objectives will be achieved:

a. Demonstrate the ability of the capsule and ground complex to initiate an acceptable re-entry after an orbital flight.

b. Demonstrate the ability of ground range stations to perform the necessary monitoring and control functions during flight.

c. Establish the adequacy of the location and recovery procedures associated with re-entry.

d. Qualify the capsule primary systems for exit and re-entry flight.

e. Determine the capsule full-scale motions and afterbody heating rates during re-entry.

f. Evaluate the capsule environment for a one orbit flight, using the crewman simulator. This test will determine the capsule's environmental systems capabilities, for human inhabitation during the entire mission from pre-launch through the post-landing phase.

1-26. Crewman Simulator

The support couch is not installed in Capsule No. 8. Instead, an instrument package and a crewman simulator are installed. (See Figure 1-7.) The crewman simulator is a box-like structure containing a carbon dioxide tank, water tank, strip heaters, valves and controls. This device simulates the carbon dioxide output, perspiration output, and oxygen consumption of a human being. The simulator is calibrated prior to flight and is activated automatically when the capsule special instrumentation package is energized.

1-27. Instrument Panels

Capsule No. 8 instrument panels are similar to the Specification Compliance Capsules. See Figures 1-12 and 1-13 for Capsule No. 8 instrument panel configurations.

1-28. Food, Water and Waste Storage

Capsule No. 8 will not contain food, water and waste containers.

1-29. Cameras

The camera installation in Capsule No. 8 will consist of an Instrument Observer Camera, an Earth and Sky Camera and a Periscope Observer's Camera. (Refer to Instrumentation Section XIII).

1-30. TEST CONFIGURATION NO. 9 CAPSULE

Capsule No. 9 is similar to the specification capsule except in the following areas. Refer to Section II for structural differences.

1-31. Mission Description

Capsule No. 9 Mission will be an Atlas, Three Orbit Flight. The primary objective of this flight will be aeromedical instrumentation of the primate and the primate's behavior in a space environment. This flight will further qualify the systems listed in Paragraph 1-25 and in addition achieve the following objectives:

a. Evaluate the effects on a primate and test the capsule environment for satisfactory conditions during prelaunch period through the post landing phase of the mission.

b. Determine in detail the heating effects of the launch and re-entry phases on capsule environment.

c. Demonstrate the integrity of the capsule structure, ablation shield and afterbody shingles for a normal re-entry from orbit.

d. Determine the capsule motions during a normal re-entry from orbit.

1-32. Support Couch

The primate support couch utilized in Capsule No. 9 (See Figure 1-7) is designed to contain, sustain and support a medium-sized primate (chimpanzee) during an unmanned capsule mission. The couch contains an instrument panel and controls to test the primate's reactions during capsule flight. This unit is essentially a two-section container. The aft section is the actual couch that supports and restrains the primate; the forward section contains the instrument panel, controls, and observation window. The primate couch, including occupant, is installed just prior to capsule launch. A Hoist Assembly packed in a plastic bag is attached to the primate couch support structure. This hoist assembly is used to assist in removing the primate couch from the capsule during recovery operations. It is located aft of, and to the right of the primate's couch and is accessible through the escape hatch opening.

1-33. Instrument Panels

The instrument panels on Capsule No. 9 are the same as used on the Specification Compliance Capsule. (See Figure 1-9.)

1-34. Food, Water and Waste Storage

Capsule No. 9 will have food and water dispensers within the couch for the primate. The waste containers are not installed.

1-35. Cameras

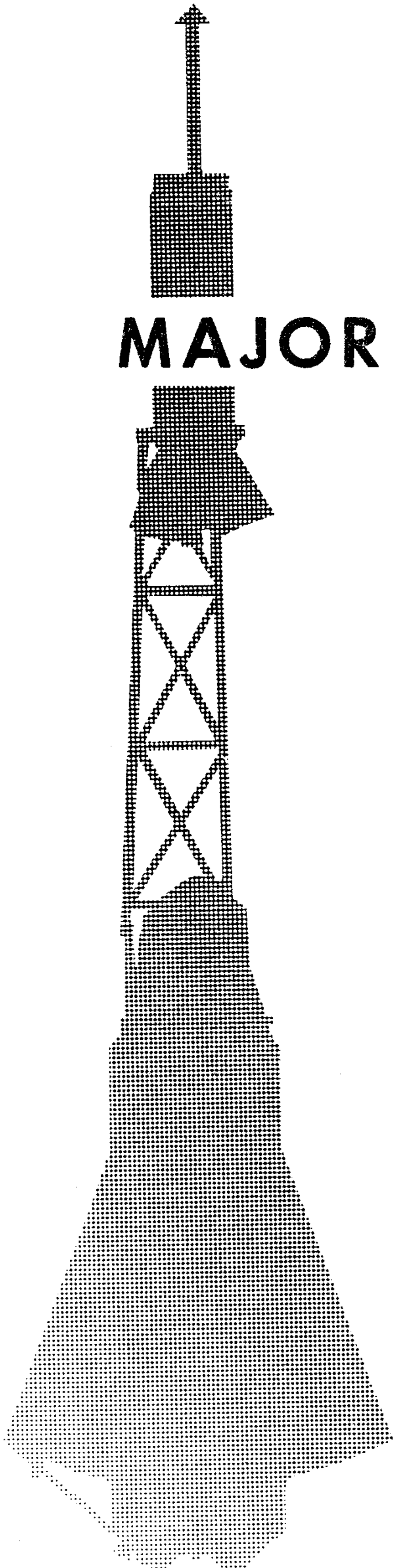
Capsule No. 9 has an Instrument Panel and Primate Observer Cameras installed. Also an Earth and Sky Observer Camera is installed which will photograph a portion of the earth and sky through the observation window. In addition a periscope camera is installed which will photograph the view displayed on the periscope. Refer to Instrumentation Section XIII.

1-36. TEST CONFIGURATION CAPSULE NO. 10

Capsule No. 10 is an orbital training simulator and altitude chamber test unit. The configuration of the capsule is subject to change during various phases of the test program; therefore, this capsule cannot be accurately described in this manual. When Capsule No. 10 is assigned to a flight mission the final configuration will be included during a subsequent revision or reissue of this publication.

1-37. TEST CONFIGURATION CAPSULES NO. 13 AND 16

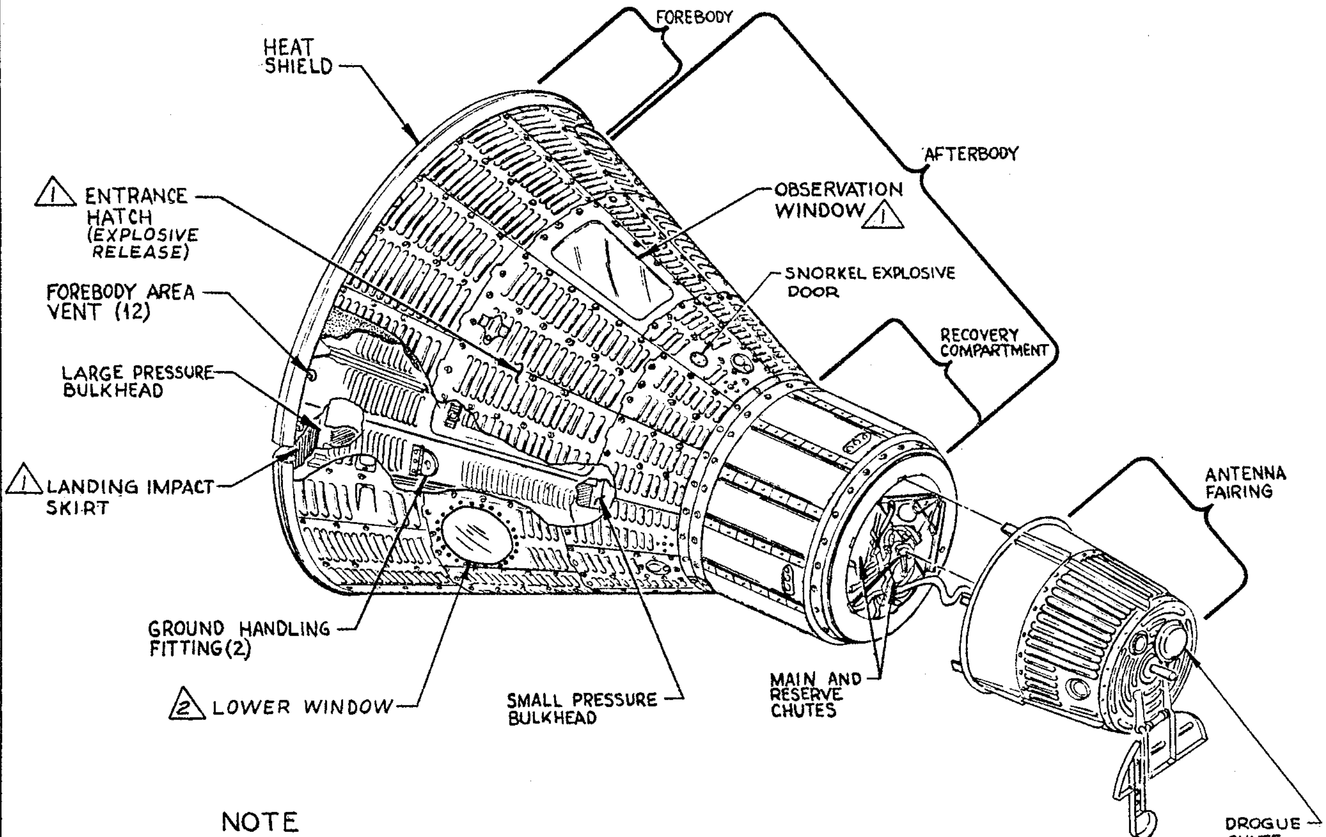
Capsule No. 13 is the same as the Specification Compliance Capsule. (Refer to paragraphs 1-1 thru 1-22).



SECTION II

MAJOR STRUCTURAL ASSEMBLIES

TABLE OF CONTENTS



NOTE

	CAPSULE
ABLATION SHIELD	8, 9, 10, 13, 16, 18, 19

⚠1 *CAPSULE 9 & UP*

⚠2 *CAPSULE 8 ONLY*

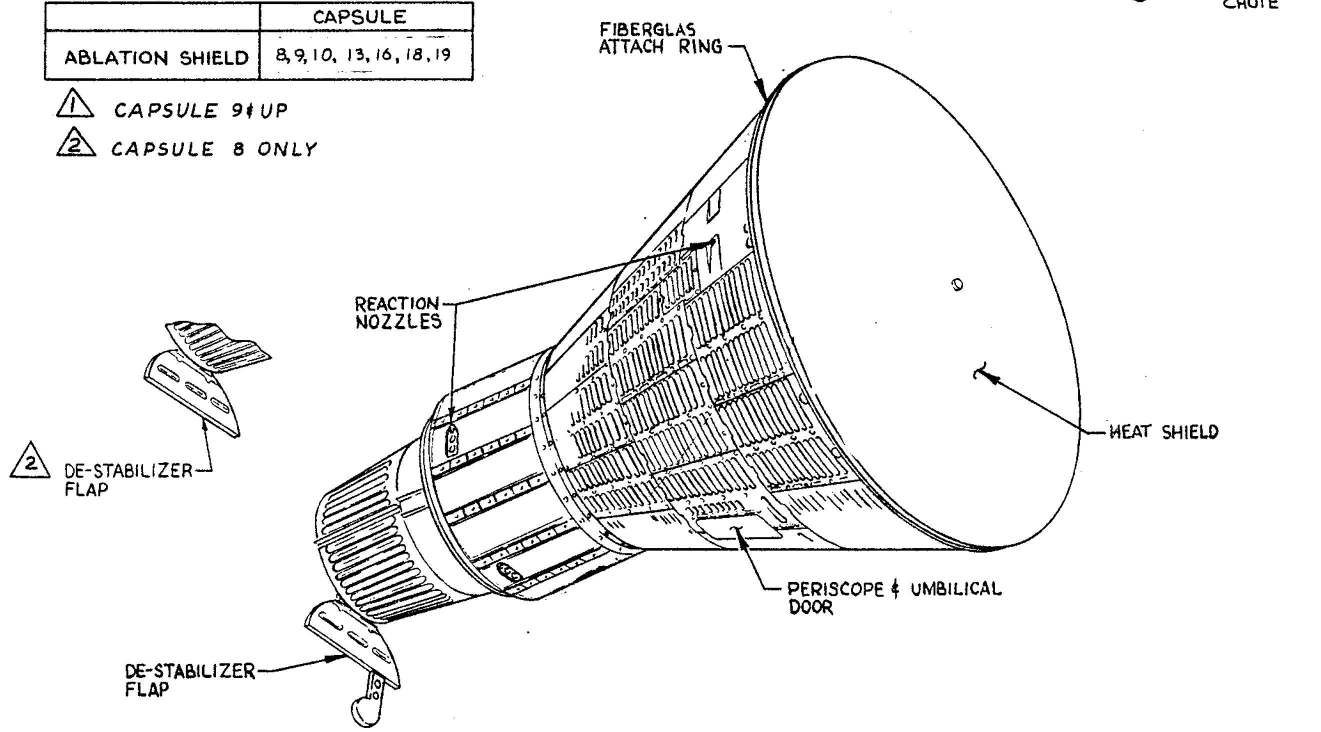


FIGURE 2-1 CAPSULE STRUCTURE (SPECIFICATION CAPSULE)

PM 45-207C

II. MAJOR STRUCTURAL ASSEMBLIES

2-1. INTRODUCTION

The Project Mercury capsule, Figure 2-1, is designed to contain an Astronaut, primate, or crewman simulator during capsule ballistic or orbital flight. Capsule payload will depend upon mission purpose. (See Figure 1-7, Section I.) The capsule will also contain recording equipment, environmental provisions, and equipment necessary to control the capsule during flight. The capsule is basically of a conical configuration consisting of a forebody and afterbody. During orbital flight, the capsule forebody is forward with respect to the capsule flight path. The capsule forebody is the large, dish-shaped structure forward of the cabin area. The capsule afterbody consists of a conical mid-section attached to a small cylindrical section. The capsule is of a conventional semi-monocoque construction utilizing titanium for the primary structure. Capsule construction is designed to protect the internal cabin from excessive heating, noise and meteorite penetration. Provisions are incorporated in the capsule to permit cabin entry, exterior viewing, normal and emergency exit.

Prior to capsule flight, an escape tower and antenna fairing are attached to the capsule afterbody cylindrical section. The escape tower, designed to aid in capsule-missile emergency separation, consists of a pylon framework equipped with rockets. The antenna fairing is a cylindrical shaped structure containing the capsule radio main receiving and transmitting antenna. The escape tower is jettisoned during the capsule launch phase or during an escape sequence. During the capsule landing phase the antenna fairing is ejected and serves to deploy the capsule main chute.

2-2. FOREBODY

The capsule forebody, Figure 2-1, mainly consists of a large, blunt, dish-shaped structure that is supported by the large pressure bulkhead and adjoins the afterbody conical section. The large pressure bulkhead internally separates the forebody from the afterbody. The forebody dish-shaped structure is an ablation heat shield that is designed to protect the capsule from extreme thermal conditions during re-entry flight. It is also designed to prevent capsule damage upon landing impact. The heat shield is attached to the heat shield attach ring, which in turn is riveted to the capsule conical section inner skin. The heat shield attach ring incorporates elongated holes, for the installation of the heat shield to the capsule and to allow for thermal expansion. The ablation shield is designed to ablate heat and is constructed of fiberglass shingles, radially laminated to form a smooth contour. A retrograde package assembly is attached to the heat shield by means of three straps. The retrograde package is jettisoned from the capsule following retrograde rocket firing, which initiates capsule re-entry.

The forebody area, between the large pressure bulkhead and the heat shield, is vented to atmosphere through a series of vents located around the periphery of the capsule forebody, adjacent to the forebody and afterbody junction. Two toroidal shaped hydrogen peroxide tanks and six reaction control nozzles, each covered with Min-K heat insulation, are located in the forebody area. The forebody area also houses the heat shield release pneumatic system. A landing impact skirt is also stored in the capsule forebody area. The rubber-cloth impact skirt, attached to the capsule heat shield attach ring and the heat shield, is designed to absorb high energy shock loads encountered during a capsule landing on land or water; and also to stabilize the capsule during

Astronaut's egress, following a capsule landing in water. During the capsule landing phase, the heat shield is released, and extends the full length of the impact skirt. Upon heat shield contact with land, air within the impact skirt is forced out through a series of holes located in the impact skirt wall which in turn provides a cushion-like effect. To prevent damage to the large pressure bulkhead in the event the heat shield strikes the capsule during landing, the large pressure bulkhead incorporates a reinforced laminated fiberglass shield assembly. The fiberglass shield assembly is attached to the torus tank support brackets. Sandwiched between the fiberglass shield and the large pressure bulkhead are sections of honeycomb. Fabricated of stainless steel and located about the periphery of the impact landing skirt, are 24 straps which prevent tearing of the impact landing skirt during high horizontal velocity water landings. Located inside the impact landing bag and alternately located in relation to the steel straps, are 24 stainless steel cables. The cables retain the heat shield to the capsule in the event strap failure should occur. The afterbody conical section exterior shingle arrangement extends beyond the large pressure bulkhead, to the forebody heat shield, and encloses the equipment located between the large pressure bulkhead and the heat shield. Located adjacent to the capsule forebody and afterbody juncture, and bolted to the heat shield attach ring, is a fiberglass attach ring. During capsule-adapter installation, the fiberglass attach ring and the adapter attach flange are clamped together with a segmented clamp ring. Receptacles for the capsule retro-package, adapter, and the clamp ring pneumatic and electrical connectors are located under the forebody shingles adjacent to fiberglass attach ring. Six spring loaded access doors, for the receptacles are incorporated in the shingles.

2-3. AFTERBODY

The capsule afterbody conical mid-section mainly consists of a pressurized cabin that is supported between a small pressure bulkhead and the large pressure bulkhead. The cabin interior wall is lined with channeled frames to provide additional structural strength and equipment attach points. The mid-section is constructed of a conically formed inner and outer titanium shell, seam welded together. The outer skin is beaded to form small sealed pressure panels capable of withstanding high pressures and structural loads. The outer conical skin is reinforced with longitudinal hat stringers. A blanket of thermoflex insulation is bonded, in between the hat stringers, to the outer (beaded) conical skin. Min-K insulation is also installed over the hat sections and covered with a shingle arrangement. The shingle arrangement is similar to the shingle installation used on the recovery system compartment. The forward end of the conical section is attached to the forebody heat shield. The combination of the conical section beaded outer skin, the hat section reinforcements, thermoflex insulation, and external shingle installation provide the capsule with adequate heat, noise and meteorite protection.

Located in the bottom of the conical section, as viewed during capsule normal flight attitude, is a retractable door that encloses the periscope lower lens flange and the capsule ground checkout umbilical receptacle. The door, mechanically linked to the periscope housing, automatically opens and closes with periscope extension and retraction. Two auxiliary hoist fittings, attached to left and right side of the capsule, provide ground handling attach points. The hoist fittings are removed prior to capsule launch. An explosive door, namely the snorkel explosive door, is provided in the capsule shingles, between the small pressure bulkhead and the capsule conical-cylindrical sections juncture. This door is exploded from the capsule during capsule landing. The exploding of the door from the capsule enables cool air to be drawn into the capsule through the snorkel valve when the cabin air inlet valve opens.

2-4. <u>Entrance Hatch</u>

An entrance hatch, Figure 2-2, is located on the right side of the after-body conical section as viewed from the capsule crew member station. Entrance hatch construction, similar to the conical section construction, consists of an inner and outer (beaded) skin seam welded together and reinforced with hat stringers. A waste container and the Astronaut's knife are attached to the hatch. An explosive charge, moulded in the hatch sill, is provided to quickly release the hatch and enable the Astronaut to egress rapidly from the capsule. An explosive charge initiator, located in the upper aft corner of the hatch, is linked to an internal release control initiator. Prior to capsule launch, the hatch is bolted and sealed into position with bolts, and two corrugated shingles are installed over the hatch. The bolts are inserted through the entrance hatch sill, which incorporates the explosive charge, and threaded into the capsule sill. A magnesium gasket, with inlaid rubber, forms the hatch seal when the hatch is bolted into position. Two hatch shingles are attached to the hatch stringers, but in no manner are they attached to capsule shingles. (This enables the hatch to separate cleanly, upon ignition of hatch explosive charge.) Following capsule impact, the Astronaut removes the initiator cap from the initiator, and the safety pin from the initiator plunger. By depressing the initiator plunger, the initiator's two spring-loaded firing pins strike the explosive charge percussion caps and detonate the explosive charge. This action explodes the hatch from the capsule. An exterior hatch release control is also provided to enable ground personnel to explode the hatch in the event the Astronaut is unable to do so. Hatch retention springs, secured by pip pins, are incorporated on the inner side of the entrance hatch to prevent injury to ground personnel in the event the initiator plunger is accidently depressed.

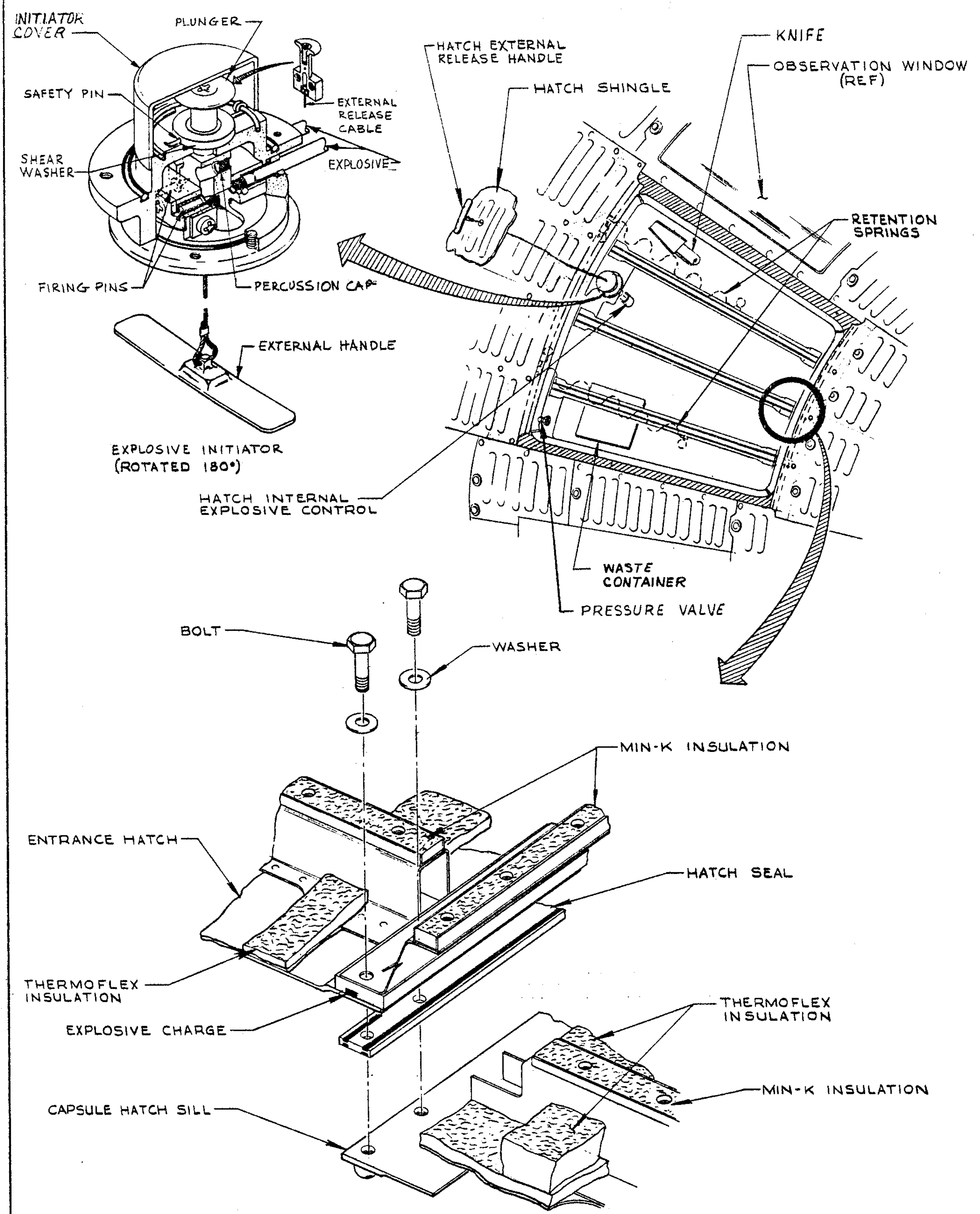


FIGURE 2-2 CAPSULE ENTRANCE HATCH (EXPLOSIVE RELEASE)

PM 45-142C

Two pressure valves, located in the hatch, enables pressurization and purging of the capsule, during capsule ground checkout operations.

2-5. Observation Window

An observation window, Figure 2-3, located on the afterbody conical section, provides the Astronaut with external viewing. The window, located above the main instrument panel, consists of an inner and outer assembly. The inner window assembly is made of three glass panes and a fourth image suppression filter pane. The three glass panes are sealed in a titanium frame that is attached to the cabin wall. Each glass pane is independently sealed to provide a pressure seal between the panes. The image suppression filter pane eliminates secondary (reflected) images. The filter pane is not pressure sealed. The outer window assembly consists of a glass pane sealed in a titanium frame, that is attached to the capsule outer skin. The outer window assembly is sealed separately, from the inner window assembly, to provide a complete seal. The outer window conforms to the curvature of the capsule conical section. The observation window is equipped with filters and door lids, enabling the Astronaut to regulate external light entering the cabin. The observation window includes a mirror assembly which increases the Astronaut's angle of observation.

2-6. Small Pressure Bulkhead

The small pressure bulkhead internally separates the cabin pressurized area from the recovery system compartment and structurally supports the aft conical section. A sealed escape hatch, Figure 2-4, internally actuated, is provided in the small pressure bulkhead to enable the Astronaut's exit following capsule landing. The dish-shaped escape hatch is constructed of a beaded aluminum skin spotwelded to an inner skin, that is reinforced with structural "Z" shaped members. The hatch outer flanged edge fits into the small pressure

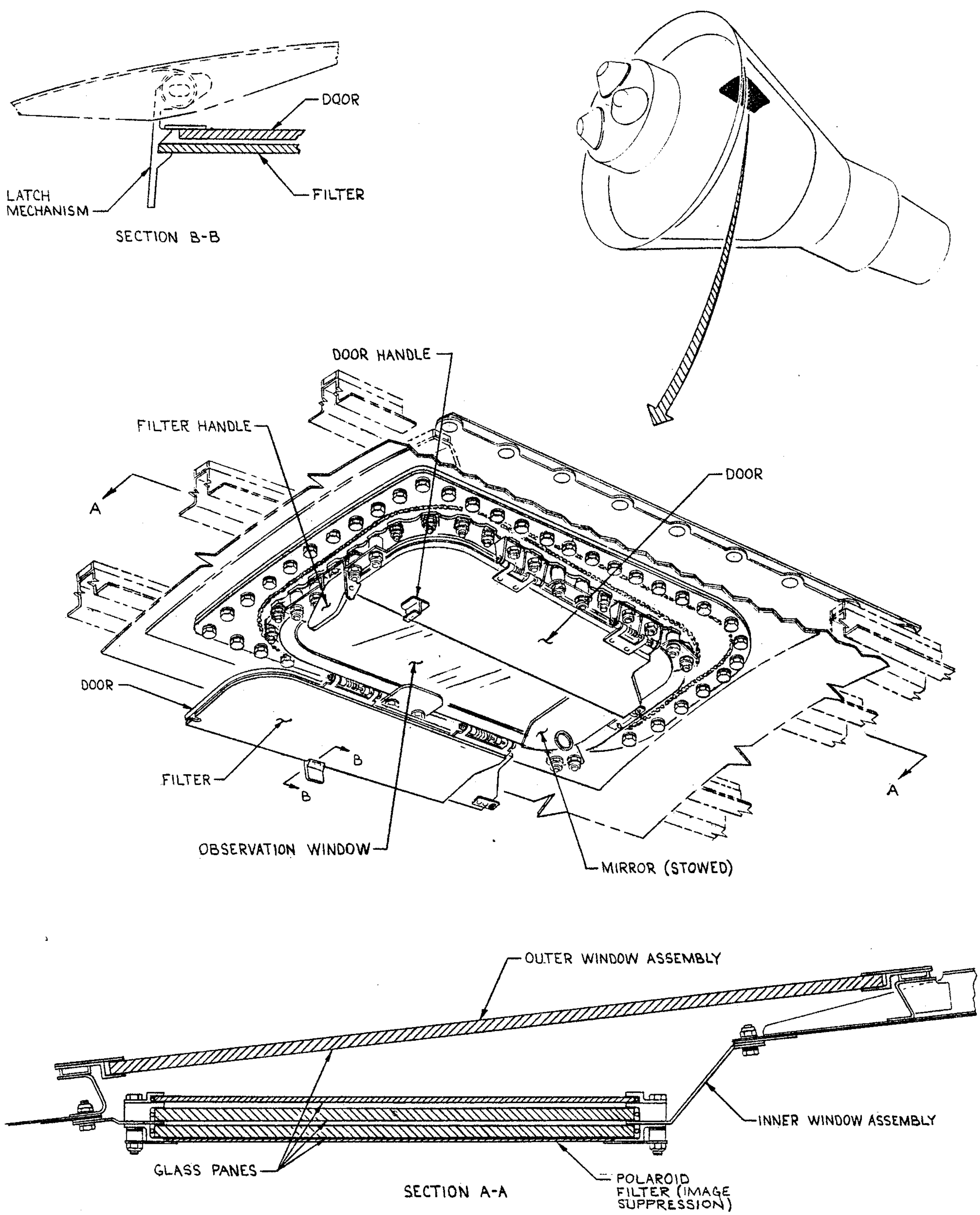


FIGURE 2-3 CAPSULE OBSERVATION WINDOW

PM45-145

bulkhead sill and is held in place with a retaining ring. Expanding the retainer ring by raising the hatch handle, wedges the retainer ring between the bulkhead sill and the hatch flanged edge and forces the hatch flange aft to provide a sealing action. The titanium small pressure bulkhead is seam welded to the conical section inner skin and bolted to the conical hat stringer flanges.

2-7. Large Pressure Bulkhead

The large pressure bulkhead supports the forward end of the conical section and internally separates the pressurized cabin from the forebody heat shield. The large pressure bulkhead is constructed of a combined inner and outer titanium skin. The outer skin is beaded and seam welded to the inner skin. The bulkhead is reinforced with horizontal channels installed on the outer skin. The bulkhead inner skin is provided with two vertical channels, centrally located and spaced, that furnish structural attach point for the Astronaut support couch. Honeycomb shelves are provided on the bulkhead inner skin, outboard of the two vertical channels, for equipment installation. The bulkhead outer flange ring is bolted to the conical section inner skin and the bulkhead is also bolted to the conical section inner attach ring. Vents are provided in the large pressure bulkhead to enable overboard venting of the capsule battery vapors and environmental control system exhaust steam.

2-8. RECOVERY COMPARTMENT

The capsule afterbody, Figure 2-1, basically consists of the short cylindrical section and the truncated cone shaped structure. The cylindrical section is referred to as the capsule recovery system compartment and contains the landing parachutes, recovery aids, and the reaction control nozzles. The truncated cone shaped structure, referred to as the capsule afterbody conical section, encloses the pressurized cabin. The recovery compartment is connected to the pressurized cabin by a small pressure bulkhead. The recovery system compartment

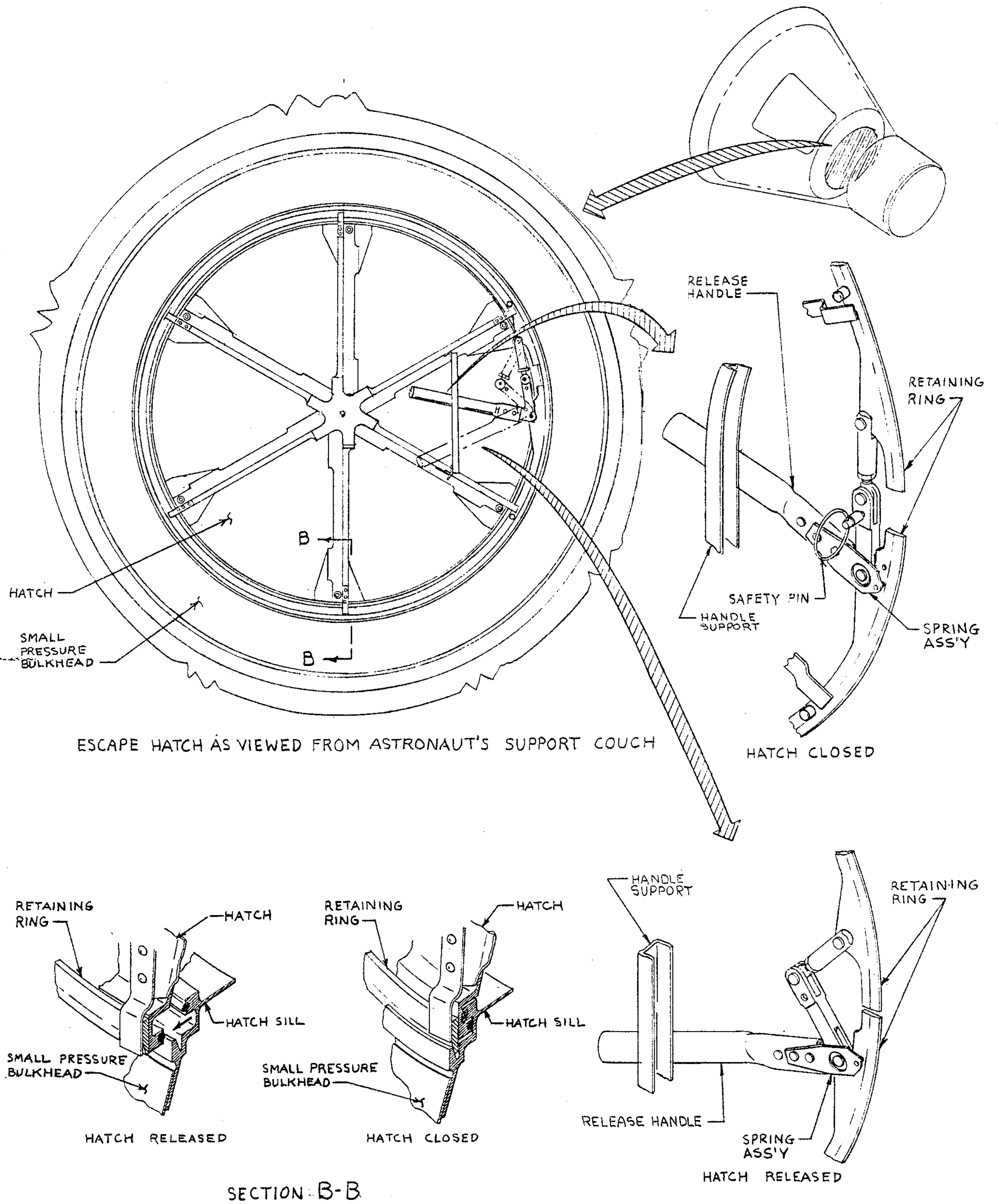


FIGURE 2-4 CAPSULE ESCAPE HATCH

PM45-18B

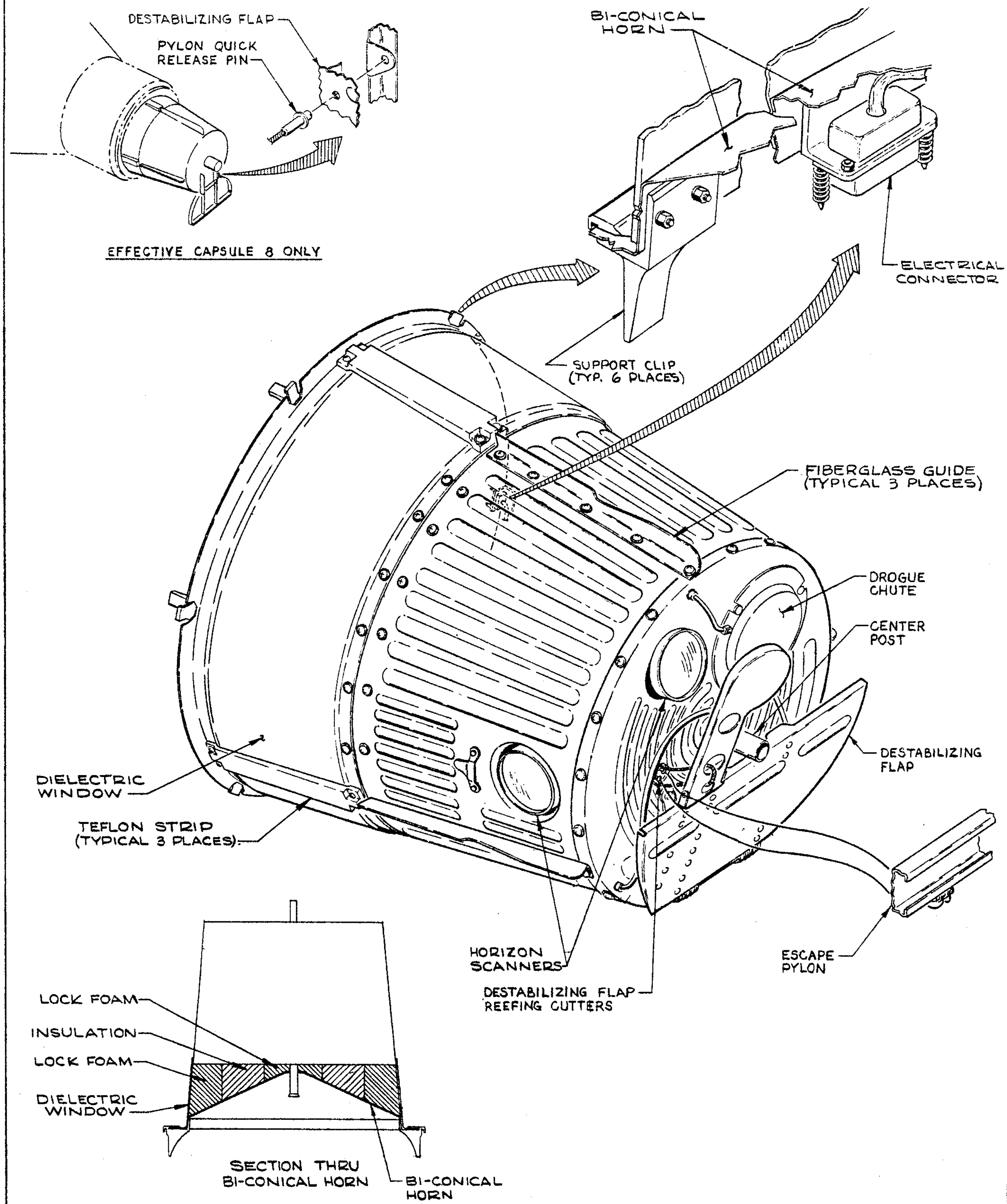


FIGURE 2-5 ANTENNA FAIRING

is a cylindrical formed titanium skin structure, reinforced with longitudinal hat stringers, and covered with a corrugated beryllium shingle arrangement. A layer of thermoflex insulation is installed between the hat stringers and the external shingles to prevent excessive heating within the compartment. The shingles are individual panels bolted to the hat sections with allowances for thermal expansion. A set of reaction control exhaust nozzles are internally located every 90°, between the compartment inner skin and the external shingle installation. The recovery system compartment interior is structurally divided into a left and right section. The compartment left section houses the recovery aids, electrical wiring and plumbing routed through the compartment. The right section of the compartment houses a fiberglass container, structurally divided into two sections that contain the main and reserve parachutes. The container can be removed by the Astronaut from the cabin following capsule landing, to permit egress through the recovery compartment.

2-9. ANTENNA FAIRING

The capsule antenna fairing, Figure 2-5, is a cylindrical shaped structure that houses the pitch and roll horizon scanners, and the main receiving and transmitting antenna. The antenna fairing basic structure is of titanium construction and is covered with "Rene-41" shingles. An 8 inch window assembly is located around the outer base of the fairing and acts as a dielectric between the top of the fairing and capsule. The window assembly consists of a silicone base, fiberglass insulation, vycor glass and teflon strips. In line with the three teflon strips and attached to the antenna fairing shingles, are three laminated fiberglass guides. The fiberglass guides and teflon strips prevent damage to the antenna fairing when the escape tower is jettisoned. An aluminum bi-conical horn is internally located at the base of the antenna fairing. An electric

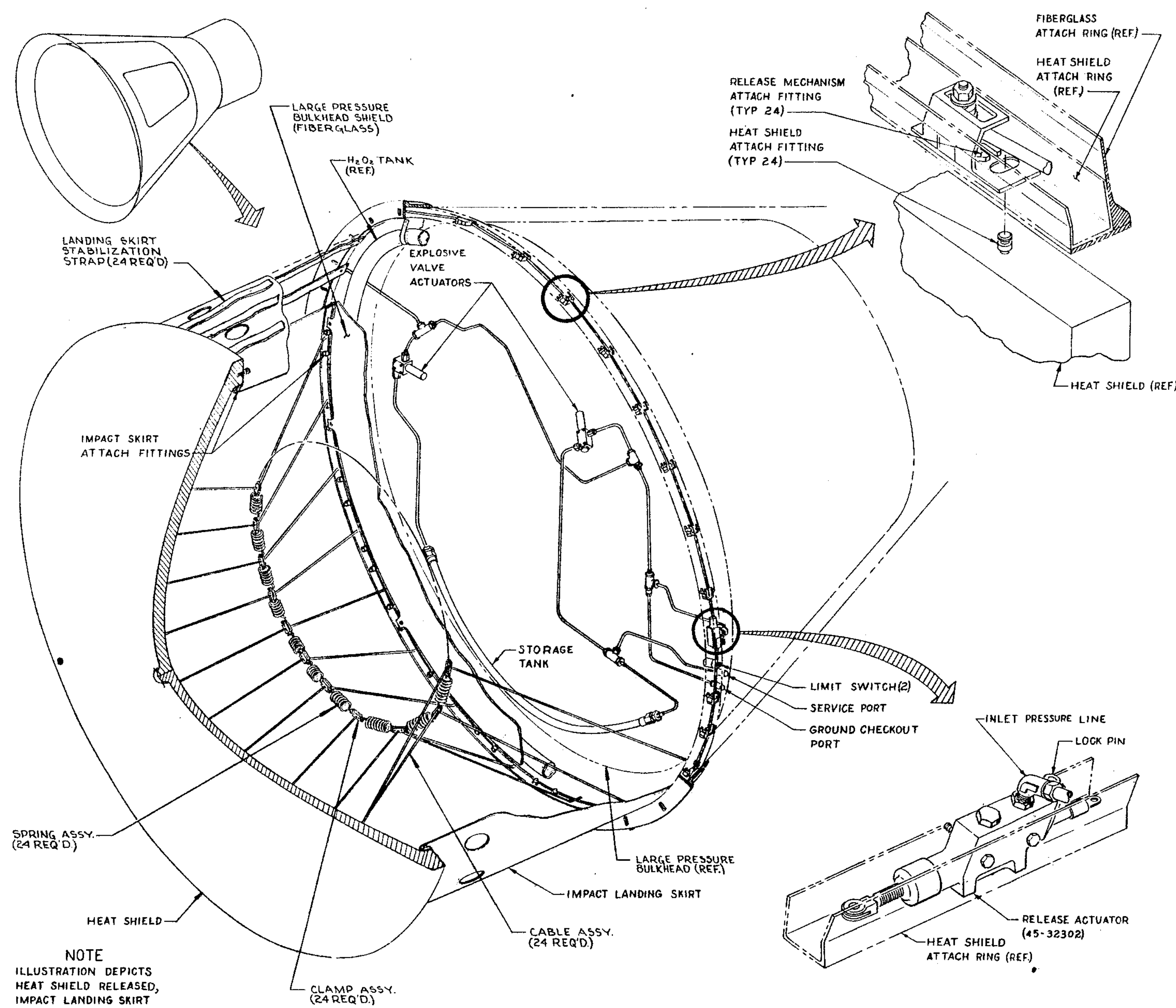


FIGURE 2-6 IMPACT LANDING SYSTEM

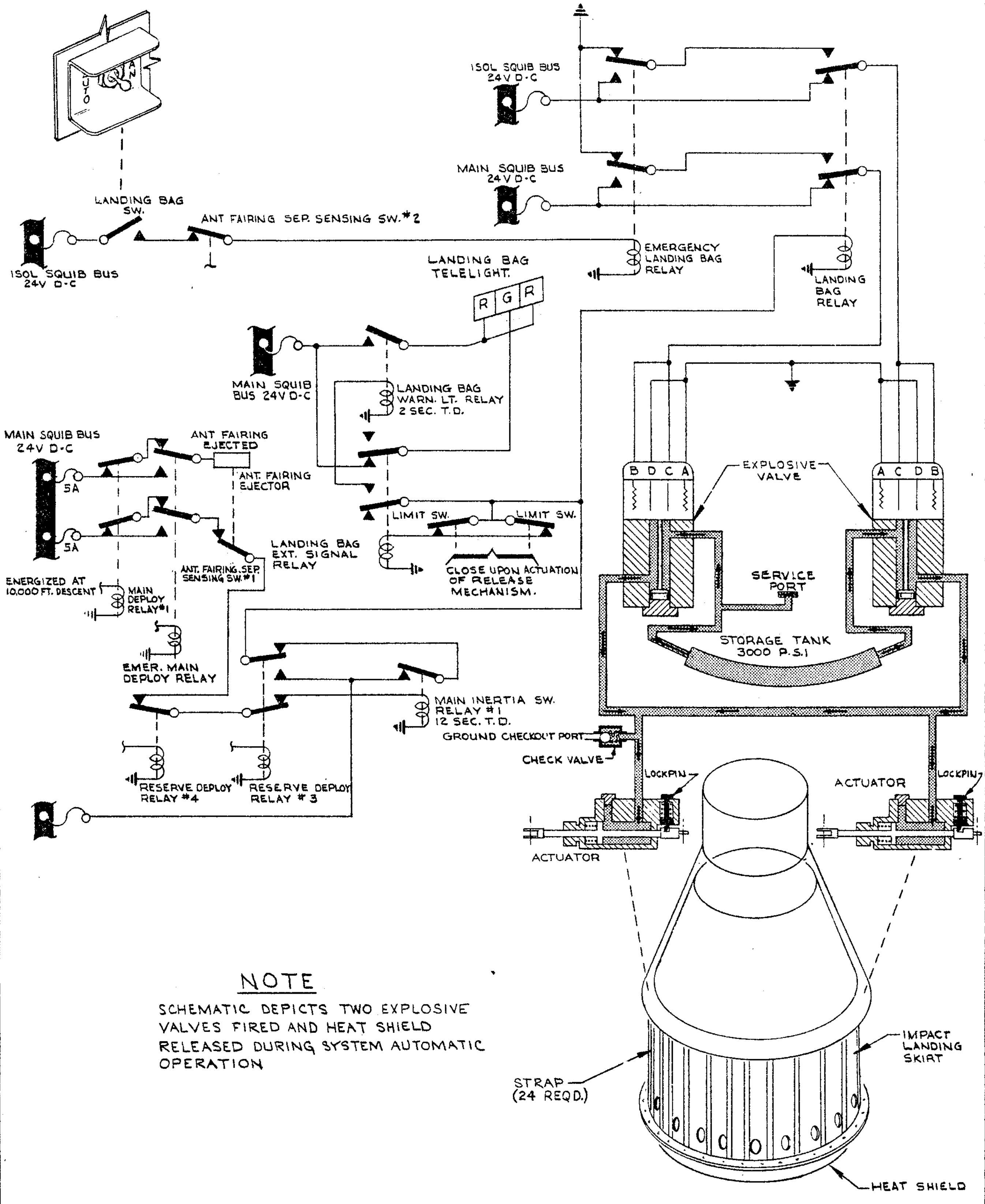
insulator and lockfoam, located above the bi-conical horn, aid in antenna fairing insulation. A pitch horizon scanner is located at the top of the antenna fairing. A roll horizon scanner is located in the side of the fairing, in line with the pitch horizon scanner. The fairing is attached to the capsule by a mortar gun located in the capsule recovery compartment. A steel post located in the center of the fairing is used as a guide when the fairing is jettisoned. Three index pins and six support clips, in the antenna fairing lower mating flange, align with three holes and six brackets in recovery compartment mating flange. The antenna fairing also houses the drogue chute. Three cables retain the drogue chute risers to the fairing when the chute is deployed.

2-10. De-Stabilizer Flap

A spring loaded de-stabilizer flap is attached to the top of antenna fairing, opposite the pitch horizon scanner. The de-stabilizer flap ensures capsule correct re-entry attitude during capsule abort and re-entry phases. During capsule launching phase, and up to the capsule-tower separation, the spring loaded de-stabilizer flap is held flat against the antenna fairing by means of a nylon cord routed through two de-stablizing flap reefing cutters contained within the antenna fairing housing. Jettisoning of the escape tower actuates the cutters which sever the cord releasing the spring loaded flap to the outboard position. When the capsule descends to 10,000 feet altitude, the antenna fairing is automatically jettisoned from the capsule by the firing of the fairing mortar gun.

2-11. IMPACT LANDING SYSTEM

The capsule impact landing system, Figure 2-6, is designed to absorb high energy shock loads encountered during landing; and also to stabilize the capsule following a landing in water. The impact system basically consists of a heat shield release mechanism, heat shield retaining straps (24), heat shield reten-



NOTE

SCHEMATIC DEPICTS TWO EXPLOSIVE VALVES FIRED AND HEAT SHIELD RELEASED DURING SYSTEM AUTOMATIC OPERATION

FIGURE 2-7 IMPACT LANDING SYSTEM SCHEMATIC

MH45-221C

tion cables (24), a rubberized cloth impact skirt and a fiberglass shield assembly. The impact skirt is stored in the capsule forebody area. During the capsule normal landing phase, the capsule 10,000 feet barostats energizes the Main Deploy Relay to eject the antenna fairing, which in turn deploys the main parachute. (See Figure 2-7.) Ejection of the antenna fairing closes the antenna fairing separation sensing switch, which in turn directs 24 V D-C electrical power to the Main Inertia Switch Relay #1 (time delay relay). Twelve seconds later, the Main Inertia Relay #1 energizes to direct electrical power to the heat shield release system limit switches and also to energize the Landing Bag Relay. Energizing the Landing Bag Relay directs 24 V d-c electrical power to ignite the 2 heat shield release explosive squib valves.

Ignition of the squib valves allows 3,000 psig nitrogen pressure to flow to the 2 heat shield release mechanism actuators. This action moves the heat shield from the capsule. Simultaneously with the actuation of the release mechanism, the mechanism 2 limit switches close to energize the Landing Bag Extension Signal Relay. Energizing the signal relay, directs electrical power to illuminate the Landing Bag Telelight (green), indicating a safe condition. When the actuator piston fully travels to the open limit, the actuator is locked by a spring loaded lock pin.

In the event the heat shield mechanism failed to actuate, and release the heat shield, the two limit switches will remain open and the Landing Bag Warning Light Relay will energize within 2 seconds. This in turn directs power to illuminate the Landing Bag Telelight (red), indicating an unsafe condition to the Astronaut. The Astronaut should place the LANDING BAG SWITCH to the "MAN" position. Placing the landing switch to the manual position energizes the Emergency Landing Bag Relay, which in turn provides power to ignite the 2 heat shield release explosive squib valves. Ignition of squib valves will actuate

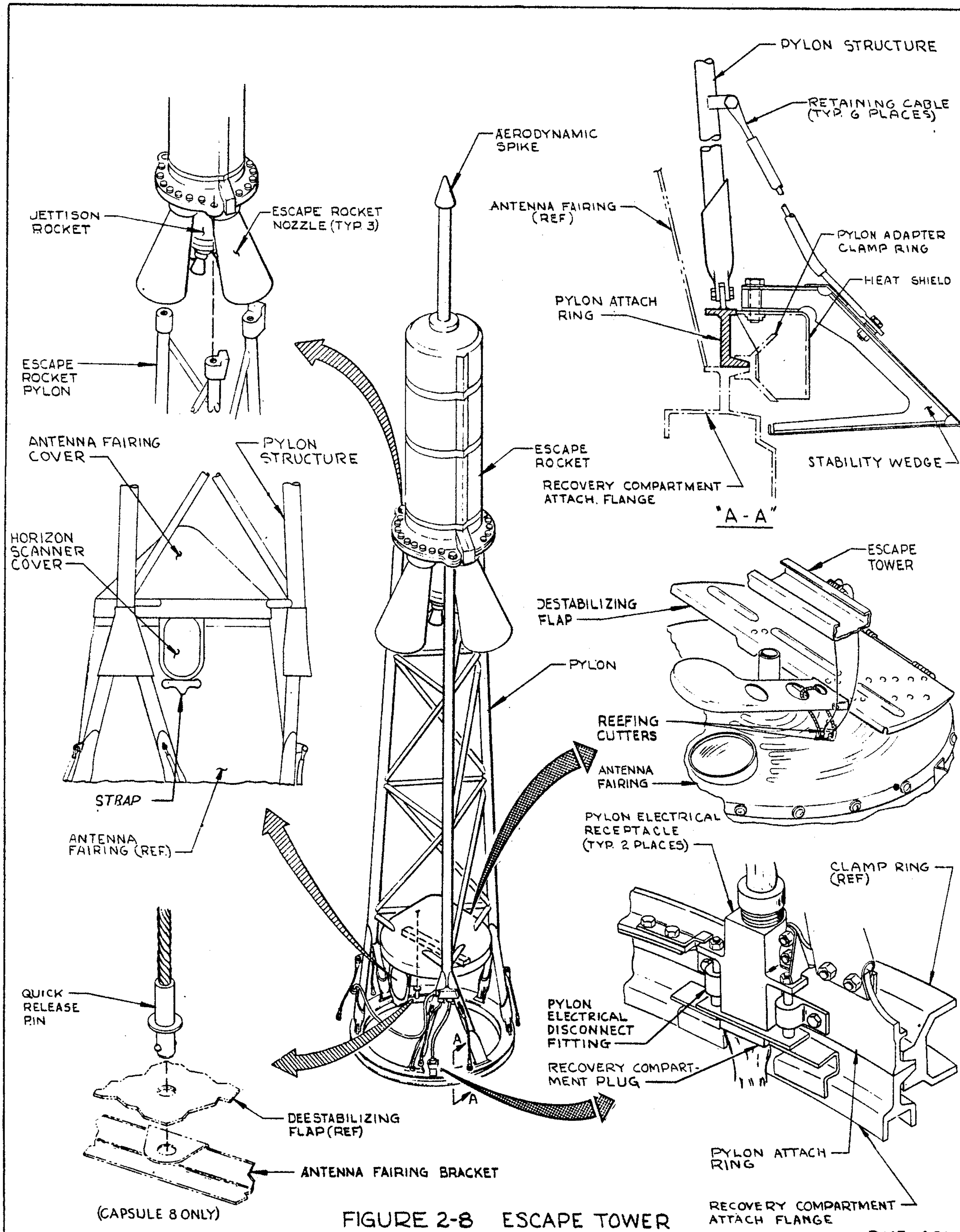


FIGURE 2-8 ESCAPE TOWER

the mechanism to release the heat shield, and in turn the limit switches will close to illuminate the telelight (green).

2-12. ESCAPE TOWER

The escape tower (Figure 2-8), designed to aid in Capsule-missile emergency separation, consists of a pylon framework equipped with rockets. The pylon is a triangular shaped structure that is designed to support an escape rocket and a jettison rocket. The pylon is constructed of 4130 tubular steel and is approximately 10 feet in length. The base of the pylon structural tubing is bolted to a steel flanged attach ring. A four foot escape rocket casing is bolted to the top (apex) of the pylon. Bolted to the bottom of the escape rocket casing is a jettison rocket. Electrical wiring is routed through the structural tubing, from the rockets to connectors, located on the pylon attach ring. Pylon tubular structure is covered with heat protective material. Prior to capsule launch the pylon is installed onto the capsule, by clamping the pylon attach ring to the capsule recovery system compartment with a chevron shaped, segmented clamp ring. Explosive bolts connect the clamp ring segments in tension. The bolts are fired to separate the clamp ring when the pylon is jettisoned from the capsule. During capsule normal launch the escape rockets are fired to separate the pylon from the capsule. In the event the capsule escape system is activated, during launch phase, the escape tower is fired to propel the capsule away from the missile and then the jettison rocket is fired to separate the pylon from capsule.

2-13. PYLON-CAPSULE CLAMP RING

The clamp ring consists of three chevron shaped segments that clamp the pylon attach ring to the capsule recovery system compartment flange. Three explosive bolts, with dual ignition provisions, connect the ring segments in tension. The clamp ring is basically the same in design as the capsule-adapter clamp ring (Figure 2-11), but considerably smaller in size. The clamp ring retains the pylon to the capsule until the clamp ring explosive bolts are fired which in turn separates the clamp ring. The exterior of the clamp ring is covered with a heat shield to protect the clamp ring and explosive bolts from excessive heating during capsule launch. A layer of thermoflex insulation is bonded to the interior of the heat shield. The heat shield is attached to the clamp ring with screws. An aerodynamic stability wedge attached to pylon heat shield, aids in stabilizing the capsule during the launch phase. Six cable straps, bolted to the pylon structure and clamp ring stability wedge, aid in capsule-pylon separation by retaining the clamp ring segments of the pylon when the explosive bolts are fired.

2-14. ATLAS MISSILE ADAPTER

The Atlas missile adapter, Figure 2-9, is a slightly tapered, cylindrical shaped structure that is designed to mate the capsule with the Atlas missile. Upon adapter and capsule installation to the missile, the adapter is bolted to the missile and the capsule is attached to the adapter. The adapter is of semi-monocoque construction and is approximately 4 feet in height. The adapter basically consists of an outer corrugated titanium skin assembly, riveted and seam welded to an inner titanium skin assembly and internally reinforced with two titanium support rings, riveted between the ends of the adapter. A steel flanged ring is riveted to the bottom, inner surface of the adapter. The flanged ring is provided with holes to enable the attachment of the adapter to the missile with bolts. Alignment marks are provided on the ring for proper adapter-missile alignment. Riveted to the top, inner surface of the adapter is an aluminum flanged ring. The adapter aluminum ring mates with the capsule forebody fiberglass attach ring, during capsule to adapter installation.

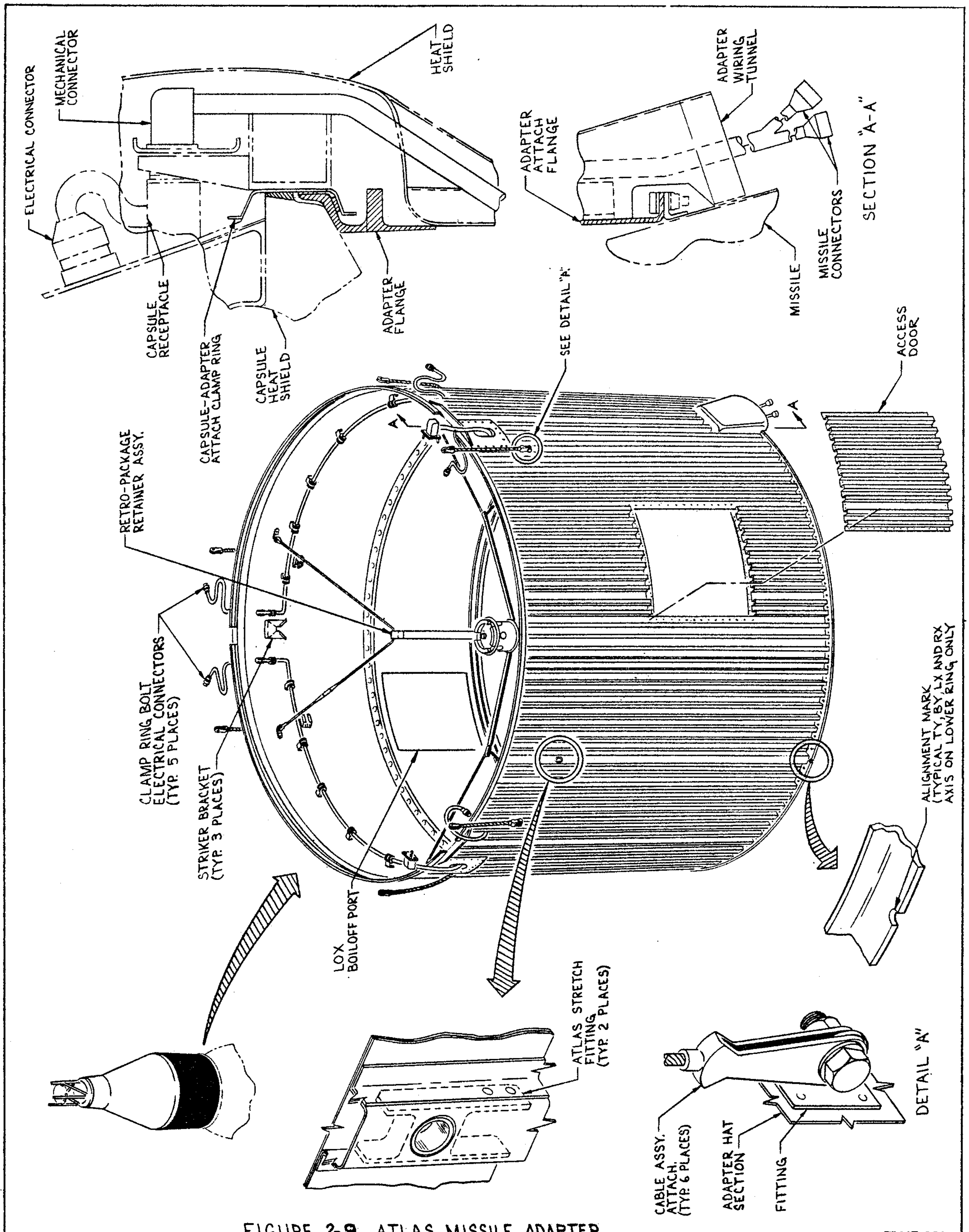


FIGURE 2-9 ATLAS MISSILE ADAPTER

PM45-23B

An alignment mark on the adapter ring BY axis enables proper alignment of capsule to adapter. The top of the aluminum ring is slotted at 120° intervals, to provide adequate clearance for the capsule retrograde rocket assembly attach straps, when the capsule is attached to the adapter. A metal striker bracket is riveted internally, every 120°, to the adapter skin. When the capsule is attached to the adapter, these striker brackets depress (open) the capsule-adapter separation sensing switches, located on the bottom of the retrograde rocket assembly attach straps. The capsule is attached to the adapter by installing a chevron shaped, segmented clamp ring over the mated flanges of the capsule forebody fiberglass attach ring and the adapter upper ring.

A retainer assembly, attached to the adapter interior skin, is provided to prevent the retro-package and the explosive bolt fragments from striking the Atlas missile adapter LOX tank. The retainer assembly is a cup shaped structure, that fits over the retro-package dome, and is supported by three metal straps that are attached to the adapter with cable assemblies. A vent port, located in the adapter skin, receives the missile boil-off valve tube and enables the relieving of liquid oxygen from the missile. Opposite the liquid oxygen boil-off port, is an adapter door installation. The door installation provides access to the booster and Capsule heat shield area while on the pad. A fiber-glass shield attached above the vent port opening, streamlines the adapter and shields the boil-off tube. Two stretch fittings, located 180° apart at the upper section of the adapter, provide a means of supporting (stretching) the missile while in the vertical position following adapter installation. Six cable assemblies, attached to fittings spaced around the adapter outer corrugated skin, are attached to the clamp ring that attaches the capsule to the adapter. The cables retain the clamp ring to the adapter following capsule-adapter separation.

2-15. CAPSULE-ADAPTER CLAMP RING

The capsule-adapter clamp ring, Figure 2-10, is provided to attach the capsule to the adapter. The clamp ring secures the capsule to the adapter throughout the capsule launching phase until the clamp ring is separated by means of explosive bolts, which in turn allows the capsule to separate from the adapter. The clamp ring consists of three chevron shaped segments, that when installed, mate with the capsule forebody fiberglass attach ring and the adapter upper support ring. Three explosive bolts, with dual ignition provisions, connect the 3 clamp ring segments in tension. A metal striker bracket is bolted, every 120°, to the inside of the clamp ring. When the clamp ring is installed, the striker brackets depress the capsule ring separation sensing switches, located in the outer periphery of the capsule forebody.

The exterior of the clamp ring is covered with a heat shield that protects the explosive bolts from excessive heating. The heat shield consists of three fairing assemblies which are located directly over the explosive bolts and three segmented fairing assemblies which cover the remainder of the capsule adapter clamp ring. The fairing assemblies which locate directly over the explosive bolts are a three piece installation. The top piece is fabricated from aluminum and the two bottom pieces are made from titanium. These fairing assemblies are fastened to the clamp ring support fittings. The interior of the fairing assemblies is insulated with thermoflex. The three segmented fairing assemblies are of a titanium construction whose interior is insulated with thermoflex. The segmented fairing assemblies are bolted to the adapter clamp ring. Six cable straps are bolted to the capsule adapter cable fitting. These straps aid in capsule-adapter separation, by retaining the clamp ring to the adapter when the explosive bolts are fired. An electrical cable, clamped around the interior of the adapter, is connected to each of the clamp ring explosive bolts, to two

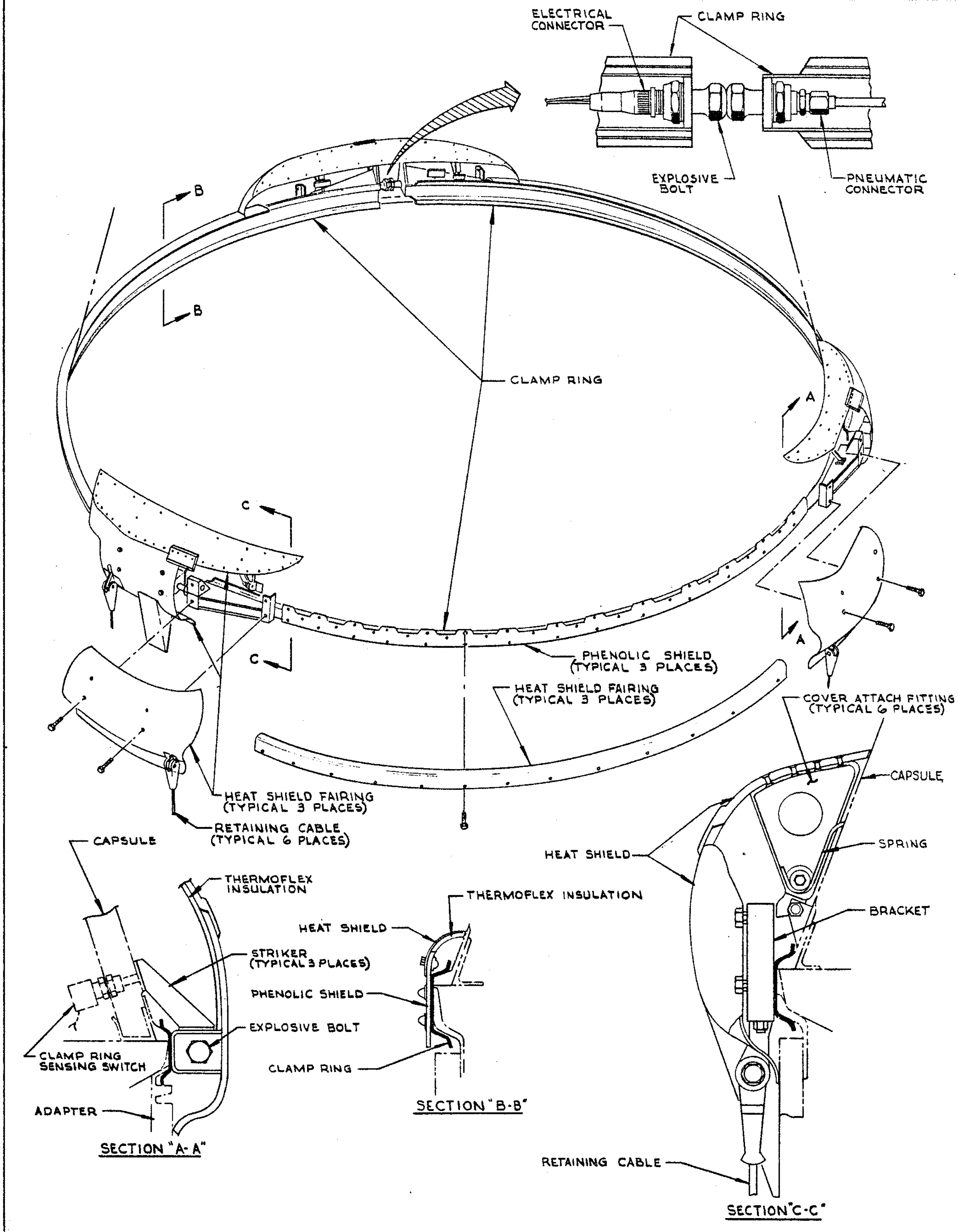


FIGURE 2-10 CAPSULE ADAPTER CLAMP RING

PM45-26

receptacles in the capsule forebody area and to two receptacles on the missile. A pneumatic line is also connected to one end of the explosive bolt and to a quick disconnect in the capsule forebody.

2-16. TEST CONFIGURATION CAPSULES

2-17. TEST CONFIGURATION CAPSULE NO. 8

Capsule 8 differs from the specification capsule in the following manner.

2-18. Forebody

Capsule 8 does not contain an impact landing skirt. Instead, the heat shield is bolted directly to the heat shield attach ring (See Figure 2-1). Capsule 8 capsule adapter clamp ring heat shield has a large frontal area in comparison to the specification capsule adapter clamp ring heat shield. Capsule 8 does not incorporate a large pressure bulkhead fiberglass shield protector. Capsule 8 Atlas missile adapter is the same as the specification capsule (See Figure 2-10).

2-19. Afterbody

Capsule 8 does not have an explosive entrance hatch (Figure 2-12). The hatch can only be removed externally. Hatch removal is accomplished by removing the attach bolts that secure the hatch to the capsule. Hatch sealing is similar to the specification capsule. The entrance hatch stringers are interlocked (bolted) with the capsule stringers when the hatch is bolted in place. Capsules 8 and 12 do not contain entrance hatch retention springs.

2-20. Windows

Capsule 8 contains two cabin windows, but does not contain an observation window (Figure 2-1). One window is located on the upper left side as viewed from the capsule crew member station, to permit Astronaut's exterior viewing. Located in the lower right side of the capsule is a window that enables the

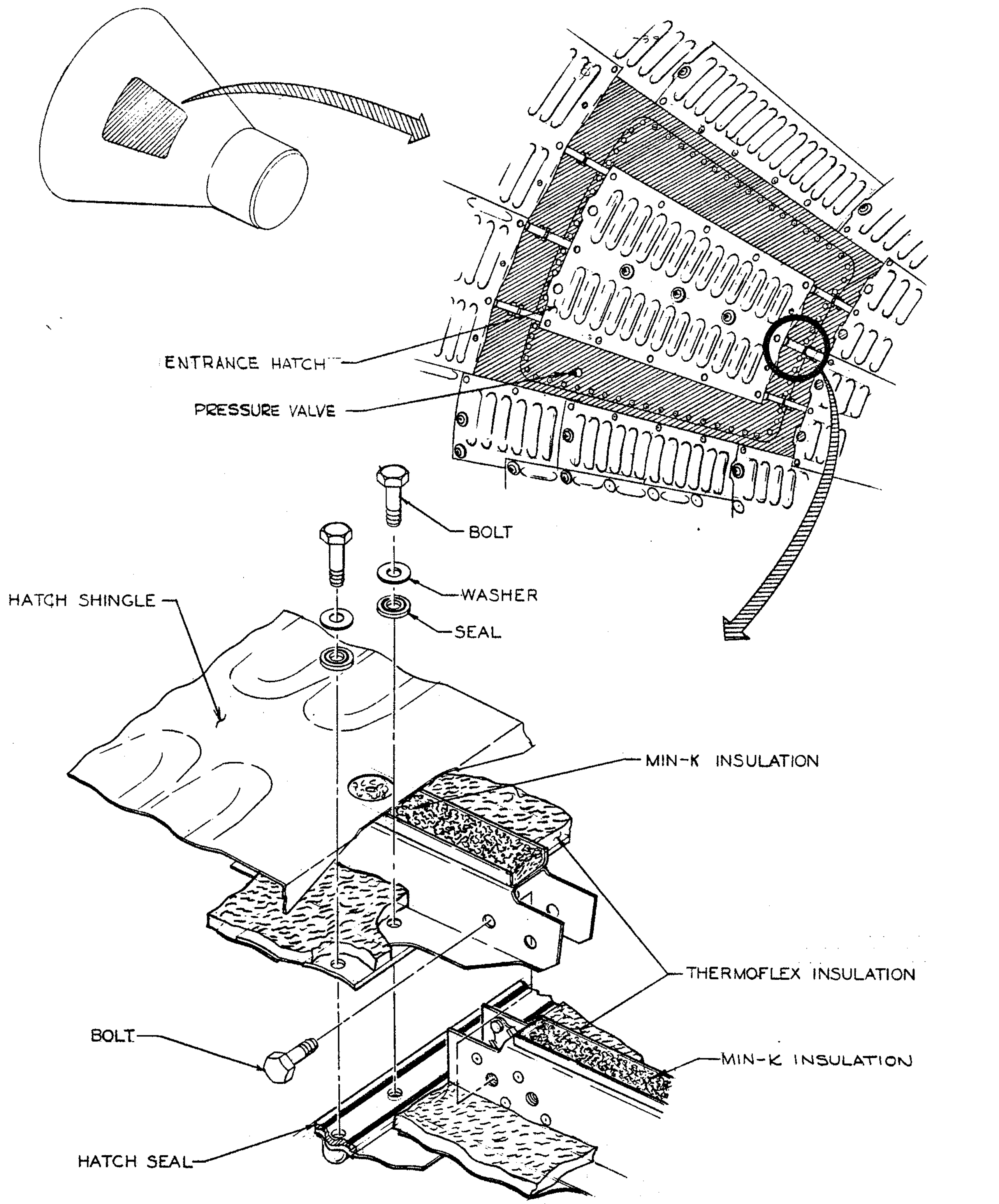


FIGURE 2-11 CAPSULE ENTRANCE HATCH

PM-43-17A

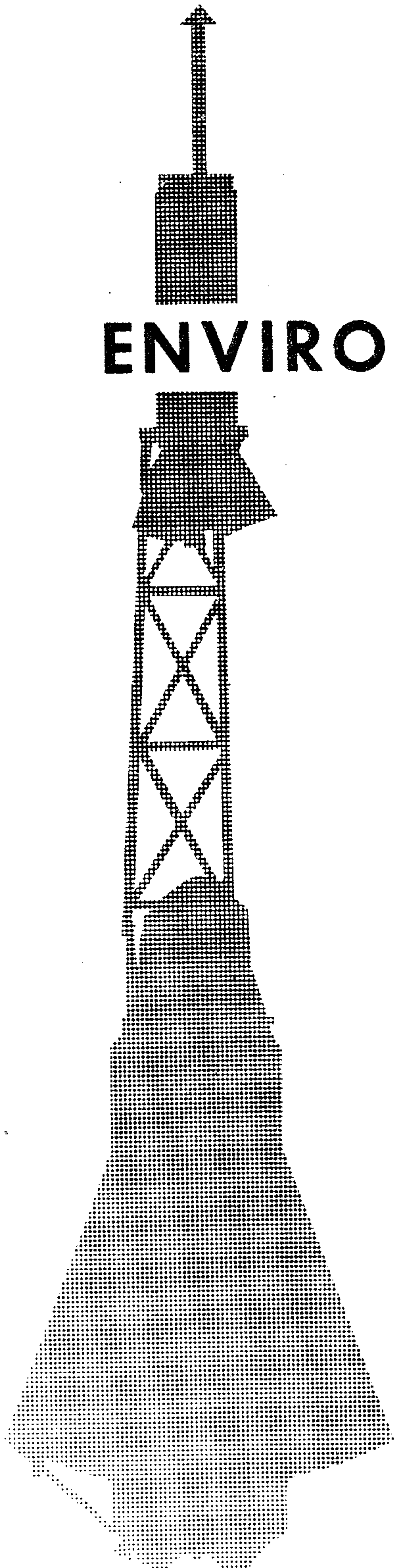
photographing of the earth and sky during capsule flight. A camera is internally located adjacent to this window. Each cabin window consists of an inner and outer window assembly. The cabin inner (main) window assembly consists of four glass panes sealed in a titanium frame attached to the cabin wall. The glass panes are spaced and independently sealed to provide a pressure seal between the panes. The outer cabin window assembly consists of a glass pane sealed in a titanium frame that is attached to the capsule outer skin. The outer pane conforms to the curvature of the capsule conical section. Capsule 8 does not incorporate a snorkel explosive door.

2-21. Antenna Fairing

The antenna fairing destabilizing flap on Capsule 8 does not contain a horizon scanner cover. (See Figure 2-1).

2-22. TEST CONFIGURATIONS CAPSULES 9, 10, 13 and 16

Capsules 9, 10, 13 and 16 major structural assemblies are basically the same as that of the specification capsule.



SECTION III

ENVIRONMENTAL CONTROL SYSTEM

TABLE OF CONTENTS

McDONNELL Aircraft Corporation
ST.LOUIS, MISSOURI

CONFIDENTIAL

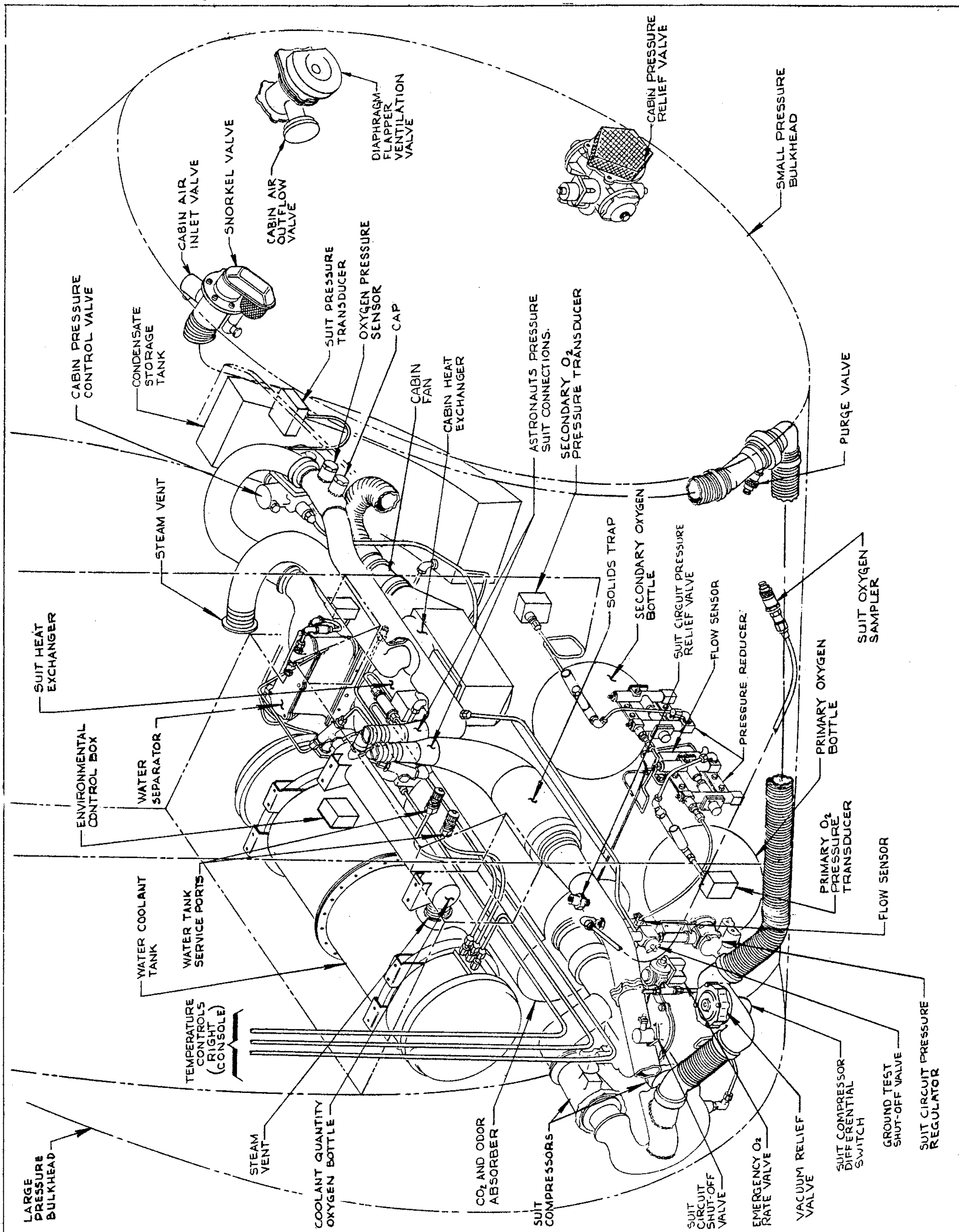


FIGURE 3-1 ENVIRONMENTAL CONTROL SYSTEM

PM45-27 D

CONFIDENTIAL

III. ENVIRONMENTAL CONTROL SYSTEM

3-1. DESCRIPTION

The environmental control system Figure 3-1, provides the Capsule Cabin and the Astronaut with a 100 per cent oxygen environment to furnish the breathing, ventilation and pressurization gas required during the capsule orbital flight and ventilation for a 12-hour post-landing phase. The environmental control system also functions in the following manner: Removes odors, CO_2 and moisture from the Astronaut's suit circuit; provides an "emergency rate" usage of oxygen in the event suit circuit pressure drops below $4.0 \begin{smallmatrix} + .1 \\ - .3 \end{smallmatrix}$ psia; maintains cabin and suit temperature at approximately $80^{\circ}F$; provides an emergency fire extinguishing capability and operates in "weightless" or "high g" conditions. System functioning will be automatically controlled during all phases of flight. In the event the system automatic control malfunctions, manual controls are provided to insure system operation.

The environmental control system is designed to be operated in either the suit mode, cabin mode or emergency mode. The system primary mode, suit environmental control, is normally utilized and enables the Astronaut to function in the closed suit circuit during cabin pressurized and emergency (depressurized) conditions. In the event one control mode malfunctions, the remaining control mode will continue to operate. The emergency mode, suit environmental control, insures Astronaut survival in the event both the suit and cabin environmental control modes malfunction. (See Figure 3-2.)

The environmental control system provides a primary and secondary oxygen supply for both the cabin and suit circuits. Primary and secondary oxygen systems are basically the same, except the secondary oxygen regulated pressure is lower than the primary oxygen regulated pressure. A manually controlled cooling circuit,

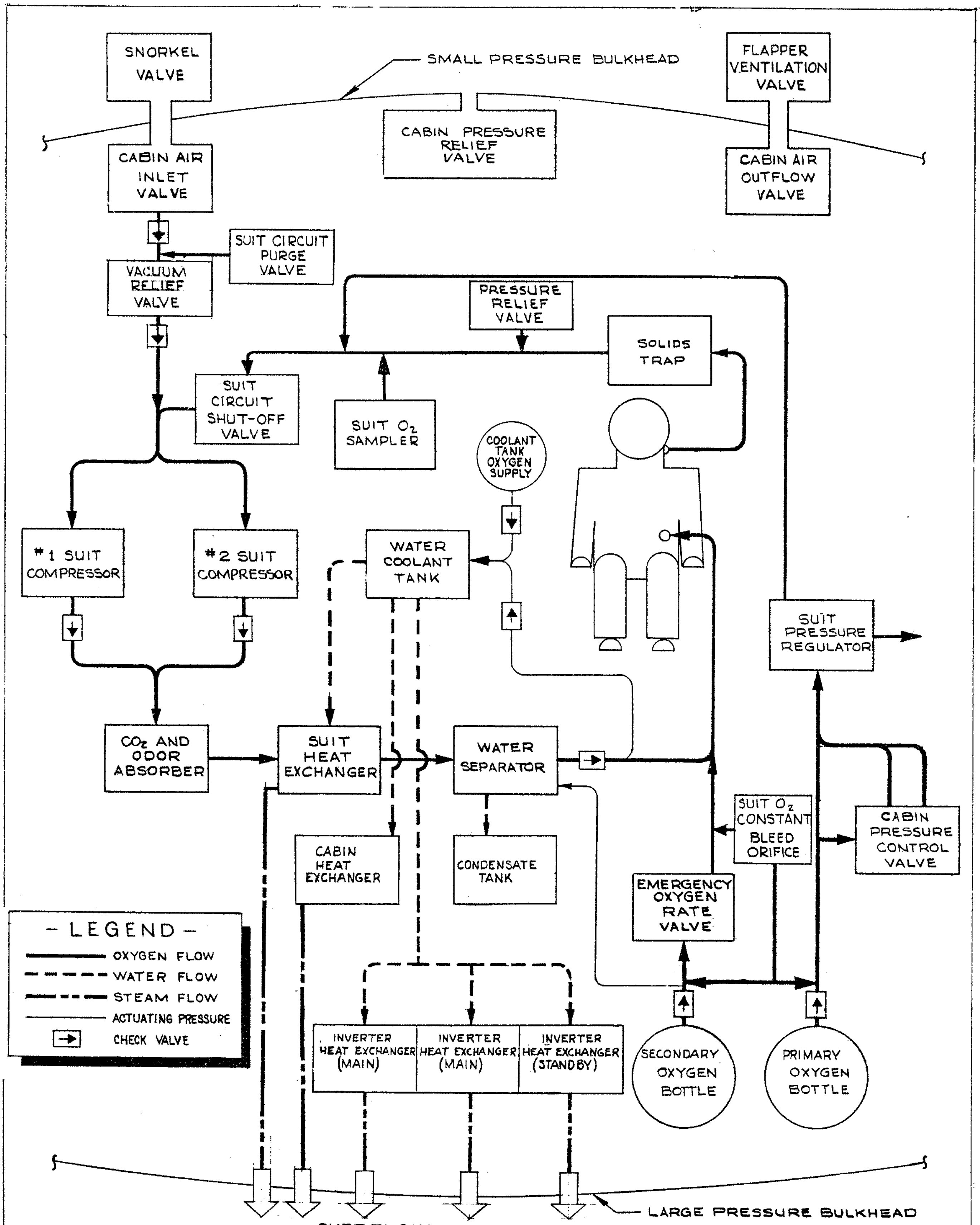


FIGURE 3-2 ENVIRONMENTAL CONTROL SYSTEM BLOCK DIAGRAM PM45-33C

for suit and cabin systems, is provided to control suit and cabin temperatures during capsule flight. The capsule environmental control system components are located below the Astronaut's support couch adjacent to the large pressure bulkhead and also on the interior of the small pressure bulkhead adjacent to the capsule escape hatch. System manual controls are located on the left and right consoles; system instruments and warning lights are located on the main instrument panel.

3-2. CABIN ENVIRONMENTAL CONTROL

During capsule normal orbital flight, the environmental control system is normally operated in both the cabin and suit environmental control mode. Operation in the cabin control mode permits the Astronaut to open his helmet faceplate for short periods of time. The capsule primary and secondary oxygen supply furnished the cabin with pressurization, breathing, and ventilation gas. The cabin is equipped with automatic and manual controls for cabin ventilation, decompression, pressurization, temperature control, landing and post landing ventilation.

The cabin is cleared of contaminants and a 100 per cent oxygen environment is made available by purging the cabin prior to launch. The purging operation is accomplished by utilizing the Capsule Leakage Tester. During orbital flight, cabin pressure is automatically controlled by a cabin pressure control valve. The cabin pressure relief valve prevents excessive pressure buildup within the cabin and provides a manual means of decompressing the cabin in the event of a fire or buildup of toxic contaminants. A water coolant supply tank, common to both cabin and suit circuits heat exchangers, provides cabin cooling. In addition to its cooling capability, the coolant tank is a source of drinking water for the Astronaut. Cabin temperature is controlled by a manually controlled selector valve, which regulates the amount of water entering the cabin heat exchanger, and in turn provides cabin cooling by means of water evaporation. The cabin fan, located on the inlet side of the heat exchanger, forces cabin air through the exchanger to provide cabin cooling and ventilation. Cabin air inlet and outflow valves, located on the small pressure bulkhead, provide ventilation during the capsule landing and post landing phase.

3-3. SUIT ENVIRONMENTAL CONTROL

During capsule normal orbital flight, the capsule common oxygen supply furnishes oxygen simultaneously to the suit and cabin environmental control circuits. If a cabin circuit malfunction, such as cabin decompression, should occur at a time when the Astronaut has his faceplate removed, the Astronaut should immediately close his faceplate. Closing the faceplate initiates the suit environmental control mode and confines the Astronaut to the closed suit control circuit.

While operating in the suit environmental control mode, the suit pressure regulator controls the suit pressure to approximately 5 psia and replenishes oxygen consumed by the Astronaut, during normal suit control circuit operation. The suit pressure regulator is supplemented by a constant oxygen bleed system as a supplier of oxygen to the suit circuit. Suit circuit pressure is also utilized as a secondary means of pressurizing the water coolant tank, in the event the coolant quantity system fails. The suit environmental control circuit incorporates compressors, filters, absorbers and a temperature control to insure Astronaut's maximum comfort. Suit circuit temperature is controlled by means of water evaporation. A water separator utilizes the common oxygen supply pressure, to remove moisture from the suit circuit oxygen supply. A compressor, located on the upstream side of the suit circuit heat exchanger, forces the suit circuit oxygen supply throughout the circuit, providing suit circuit ventilation.

During the capsule landing and post landing phase, atmospheric air is drawn in through the cabin air inlet valve to provide suit circuit ventilation.

3-4. SUIT EMERGENCY CONTROL

While operating in the suit environmental control mode during orbital flight, the suit emergency control mode automatically activates when suit circuit pressure decreases below $4.0 {}^{+.1}_{-.3}$ psia pressure. A control handle is provided to enable manual selection of the emergency mode. During the capsule landing phase, the emergency mode is automatically activated to increase Astronaut's cooling. The environmental system oxygen rate valve and the suit circuit shutoff valve actuate simultaneously to switch the environmental system from the suit environmental control mode to the suit emergency control mode. Actuation of these valves may be either automatic or manual.

Operation in the suit emergency control mode, during orbital or landing phases, basically consists of eliminating suit circuit oxygen flow through the suit CO_2 and odor absorber, heat exchanger and water separator units. During the landing phase, oxygen flow through the Compressor is maintained. During orbital phase, oxygen flow is eliminated by deactivation of the Compressor. Elimination of oxygen flow through these accessory components, while operating in the suit emergency control mode, reserves the oxygen supply to remove the Astronaut's generated heat, pressurize the Astronaut's pressure suit, and provide a breathing source for the Astronaut.

An O_2 EMERG light, located on the main instrument panel, and a tone generator indicates when the environmental system is operating in the suit emergency mode. Manual provision, to activate the suit emergency control, is located on the right console.

3-5. OXYGEN SUPPLY

The environmental system is supplied with oxygen, from primary and secondary bottles. The primary and secondary oxygen bottles are directly interconnected by a supply line, that forms a common oxygen supply to the cabin pressure control valve, suit pressure regulator, emergency oxygen rate valve, and the suit circuit water separator. The primary and secondary oxygen supply lines incorporate shut-off valves, pressure transducers, pressure reducers, and check valves. The pressure transducers transmit oxygen pressure, present in the primary and secondary oxygen bottles, to a dual quantity indicator, tape recorder, and to a telemetry unit. The primary oxygen bottle pressure is reduced to 100 $\pm$ 10 psig, by a primary oxygen pressure reducer. Two primary oxygen pressure reducers are provided to insure oxygen pressure reduction, in the event one pressure reducer fails closed. The secondary oxygen bottle pressure is reduced to 80 psig by a secondary pressure reducer. The primary oxygen supply reduced pressure, being greater than the secondary oxygen supply reduced pressure, permits the primary oxygen supply to be utilized during normal conditions with the secondary oxygen supply in reserve. The oxygen supply line check valves prevent the loss of oxygen, in the event either the primary or secondary oxygen pressure reducers malfunction.

3-6. COOLING CIRCUIT

During normal capsule orbital flight, the environmental system cooling circuit furnishes the cabin and the suit circuit with provisions for independently controlling the cabin and suit circuit temperatures. Water is supplied, under oxygen pressure, from the capsule water tank to the cabin and suit circuit heat exchangers which in turn provides cooling by evaporation. The heat exchangers absorb heat from the cabin and suit circuit oxygen and boil it off as steam.

The cooling circuit contains an independent oxygen bottle that provides pressure necessary to pressurize the water coolant tank, enabling water flow to the heat exchangers. The oxygen bottle pressure is used as a reference pressure for the coolant quantity indicator. A line, interconnected between the suit circuit line and the coolant tank pressurization line, insures water coolant tank pressurization, in the event the coolant quantity indicating system malfunctioned. The cooling circuit basically consists of a water tank, cabin and suit temperature control valves, heat exchangers, and indicators. A coolant quantity indicator, EXCESS CABIN H_2O and EXCESS SUIT H_2O lights are located on the main panel. Temperature control valves are located on the right console.

3-7. OPERATION

The environmental control system is designed to sequentially operate automatically during the launch, orbit, re-entry and post-landing phases of capsule flight. The mode in which the environmental system is operated is dependent upon the existing conditions within the cabin and suit circuits.

During the pre-launch phase of operations, the capsule oxygen and water supply are fully serviced and a capsule preflight is performed. Refrigerated air is ducted through the capsule hatch to pre-cool the capsule cabin and structure during capsule preflight. The refrigerated air supply is removed and an external supply of freon coolant is directed to the cabin and suit circuit heat exchangers, through the umbilical, to continue pre-cooling the capsule structure and cabin equipment. The oxygen supply bottles shutoff valves are opened and the Astronaut is connected to the capsule suit circuit by attaching the suit circuit personal leads (flex hoses) to the Astronaut's pressure suit. The suit compressor and cabin fan are activated. The suit circuit is purged with an external source of low pressure oxygen applied through the suit circuit purge valve. Following the purging operation, a suit circuit leakage check is performed with the Astronaut's faceplate closed. The capsule entrance hatch is bolted into position and the capsule cabin is then checked for leakage and purged with oxygen. The suit circuit incorporates provisions for obtaining launch purge oxygen samples.

Forty-five seconds prior to launch, the ground umbilical plug is disconnected and freon coolant supply to the capsule ceases. During launch and orbit, the cabin pressure relief valve maintains cabin pressure at approximately 5.5 differential (cabin/ambient) psia. During capsule launch, the suit circuit pressure regulator maintains the suit circuit pressure approximately equivalent to cabin pressure. The suit circuit oxygen is kept free of contaminants by a solids trap and a CO_2 and odor absorber. The solids trap removes foreign particles such as food particles, nasal excretions, hair, etc. The CO_2 and odor absorber filters odors and CO_2 from the circulating oxygen. Moisture from the suit circuit oxygen is removed from the system by a water separator. The pneumatically activated water separator deposits the moisture into a condensate tank. Cabin and suit circuit temperatures are controlled by manually operated metering valves, that regulate the water flow rate from the water coolant tank to the cabin and suit circuit heat exchangers. Upon reaching altitudes where the saturation temperature of water is lower than the cabin and suit circuit gas temperatures, the cabin and suit circuit heat exchangers will provide cooling by water evaporation.

Prior to capsule re-entry from orbital flight, the Astronaut positions the temperature control valves to a COLD setting. When the capsule descends to an altitude of approximately 21,000 feet, the snorkel explosive door is ejected. (Door is located on capsule exterior.) At an altitude of approximately 17,000 $\pm$ 3000 feet, the cabin air inlet and outflow valves open barometrically venting the cabin to the atmosphere. Operation of the suit circuit compressor draws outside air into the suit circuit through the ejected snorkel door opening, the snorkel valve and the open cabin air inlet valve. The air, circulating through the suit circuit, is relieved into the cabin and in turn flows out through the cabin air outflow valve. Simultaneously, with the opening the cabin air inlet and outflow valves, the environmental system mode of operation switches to the suit emergency mode, but the suit compressor continues to operate. Switching to the emergency mode provides a greater cooling capacity for the Astronaut. When the capsule descends to approximately 10,000 feet altitude, the antenna fairing is ejected. Ejection of the antenna fairing directs capsule power to ignite explosive squibs, and in turn open the cabin air inlet and outflow valves. (Opening of the cabin air inlet and outflow valves, when the antenna fairing is ejected, is provided to supply ventilation air into the cabin in the event of a capsule low altitude abort (below 17,000 feet) during capsule launch.) An inlet air snorkel valve and an outflow air diaphragm flapper ventilation valve located on the unpressurized side of the small pressure bulkhead -- opposite the cabin air inlet and outflow valves, prevent water from entering into the cabin in the event the capsule submerges after landing in a water environment. A vacuum relief valve, located in the flexible ducting between the cabin air inlet valve and suit circuit, enables suit circuit ventilation whenever the inlet snorkel valve closes. During the post-landing phase, the Astronaut may continue to operate his suit circuit compressor to provide suit circuit ventilation. The suit circuit compressor draws atmospheric air into the suit circuit, through the cabin air inlet valve.

3-8. CABIN ENVIRONMENTAL CONTROL

Operation of the environmental control system in the cabin environmental control mode, (Figure 3-3), after the capsule has entered the orbital flight path; permits the Astronaut to open his helmet faceplate and be exposed to cabin environment for short periods. The cabin circuit also provides a manual method for decompressing and repressurizing the cabin. The cabin pressure relief valve relieves cabin pressure in excess of 5.5 psia. In the event cabin pressure tends to exceed the 5.5 psia differential (cabin over ambient), the relief valve will open to relieve the excessive pressure. In the event the cabin pressure decreases below 5 psia, the cabin pressure control valve will sense the pressure drop and open. Opening of the cabin pressure control valve allows oxygen to flow into the suit circuit. The suit pressure regulator will sense the increase in suit pressure, and relieve excess pressure into the cabin. Routing the cabin pressure control valve oxygen supply through the suit circuit, provides a constant purging of the suit circuit. Cabin pressure control valve maintains cabin pressures to $5.1 {}^{+.2}_{-.3}$ psia.

During orbital flight, cabin gas is circulated throughout the cabin by the cabin fan, located at one end of the cabin heat exchanger. The cabin fan forces cabin gas through the cabin heat exchanger. The cabin gas circulating through the cabin, absorbs the heat generated by the cabin electronic equipment and in turn is cooled when the gas passes through the cabin heat exchanger. Water from the water tank circulates through the heat exchanger and absorbs the heat from the cabin gas passing through the heat exchanger. The heated water evaporates and passes overboard through the large pressure bulkhead steam vent. Regulating the amount of water entering the heat exchanger provides cabin temperature control. A cabin temperature control valve, located on the right console, is manually operated by the Astronaut to control cabin temperature.

In the event of a fire or a buildup of toxic contaminants, within the cabin, the Astronaut may manually decompress the cabin by actuating the DECOMPRESS "T" handle, located on the left console. The decompression handle is connected to the cabin pressure relief valve with a cable. During decompression of the cabin, the cabin pressure control valve closes when cabin pressure decreases to 4.1 psia. Following fire extinguishment, or the removal of toxic contaminants, the Astronaut may repressurize the cabin by closing the DECOMPRESS "T" handle and actuating the REPRESS "T" handle. The REPRESS "T" handle is connected to the cabin pressure control valve with a cable. When the cabin has been repressurized to 5.0 psia, the REPRESS "T" handle must be manually closed. In the event of a cabin decompression, due to a metorite penetration or excessive cabin leakage, the cabin pressure control valve will close automatically and prevent oxygen flow to the cabin, after the cabin pressure decreases to 4.1 psia. Closing of the cabin pressure control valve reserves the remaining oxygen supply for the suit environmental control circuit, enabling the Astronaut to continue the mission.

Prior to capsule re-entry, the Astronaut should assure that his helmet faceplate is closed, and pre-cool the cabin structure and equipment by positioning the cabin temperature control valve and suit temperature control valve to the cold settings. During capsule descent, cabin pressure is maintained at approximately 5 psia pressure, until the cabin altitude is approximately 27,000 feet. At 27,000 feet altitude the cabin pressure relief valve begins to open, allowing atmospheric air to enter the cabin and equalize capsule internal and external pressures. When the capsule reaches 17,000 ± 3000 feet altitude, the cabin air inlet and outflow valves open and the cabin fan ceases operation. Opening of the cabin air inlet valve provides outside air ventilation for the suit circuit. Suit circuit air is then vented to the cabin and out through the cabin outflow valve. If the cabin air inlet and outflow valves fail to open at 17,000 ± 3000 feet altitude, the Astronaut should actuate the SNORKEL pull ring to open the valves. In the event the Astronaut fails to open the cabin air inlet and outflow valves, the valves will open automatically at 10,000 feet when the antenna fairing is ejected. Ejection of the antenna fairing directs

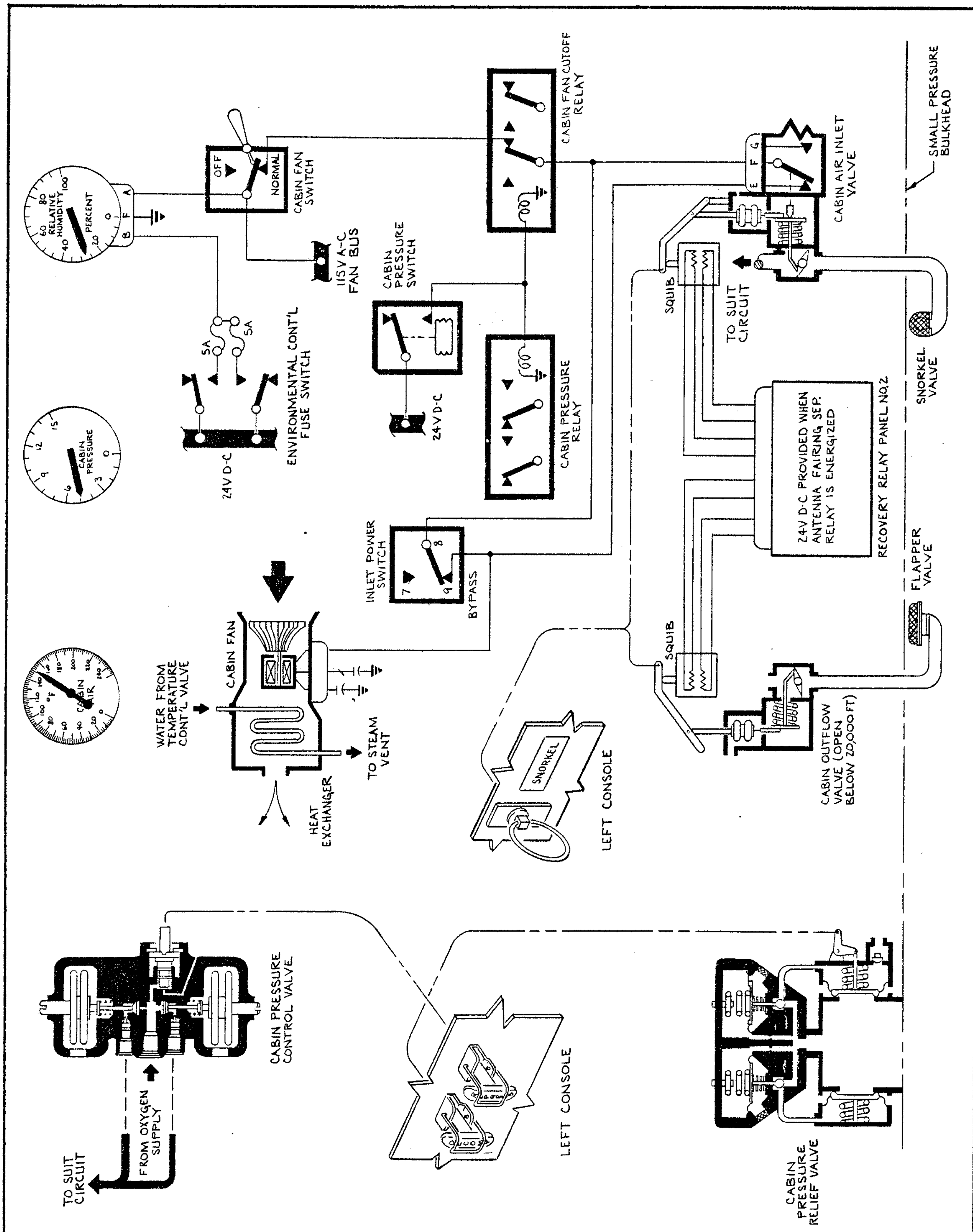


FIGURE 3-3 CABIN ENVIRONMENTAL CONTROL

PM45-280

electrical power to ignite the cabin air inlet and outlet valves explosive squibs, which in turn mechanically open the valves. A snorkel valve, provided on the inlet side of the cabin air inlet valve and a diaphragm flapper ventilation valve provided on the outlet side of the cabin air outflow valve, prevent water from entering the cabin when the capsule lands in the water. Following capsule landing, the Astronaut may operate suit compressor for ventilation.

A cabin pressure indicator and a cabin temperature indicator are provided on the main instrument panel to indicate cabin pressures and temperatures. A humidity indicator, with an incorporated sensor and amplifier, is also provided on the main instrument panel to indicate relative humidity content of the cabin gas. A CABIN PRESS light and tone generator, located on the main panel, indicate when cabin pressure has decreased below 4.0 psia pressure.

3-9. SUIT ENVIRONMENTAL CONTROL

The suit environmental control circuit, Figure 3-4, is supplied oxygen from the environmental system oxygen supply, through the suit pressure regulator and the cabin pressure control valve. During capsule launch and re-entry phases, when the Astronaut's helmet faceplate is closed, the suit pressure regulator utilizes cabin pressure as a reference to control the suit circuit pressure. While operating in the suit environmental control mode, (helmet faceplate closed), oxygen from the suit pressure regulator flows through the suit compressor, CO_2 and odor absorber, suit heat exchanger, water separator, Astronaut's pressure suit, and the suit circuit solids trap. In the event the suit circuit oxygen pressure decreases, (more than 2.5 to 3.5 inches of water below cabin pressure), the suit pressure regulator will sense the pressure drop and open, allowing oxygen to flow into the suit circuit to maintain the suit circuit pressure within 2.5 to 3.5 inches - water of cabin pressure. When not in operation, the suit environmental control system is guarded against contamination by a neoprene

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

~~CONFIDENTIAL~~

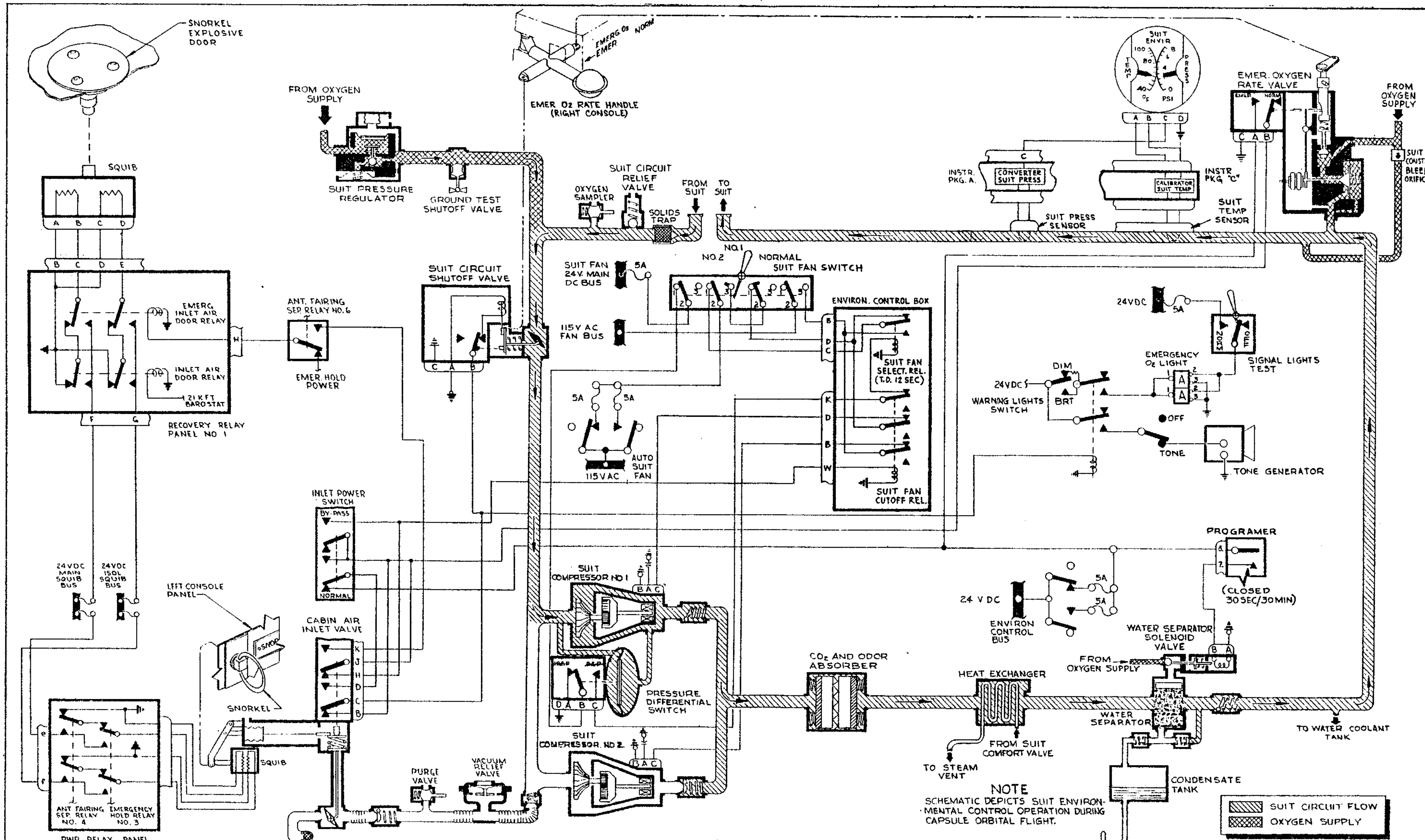


FIGURE 3-4 SUIT ENVIRONMENTAL CONTROL

~~CONFIDENTIAL~~

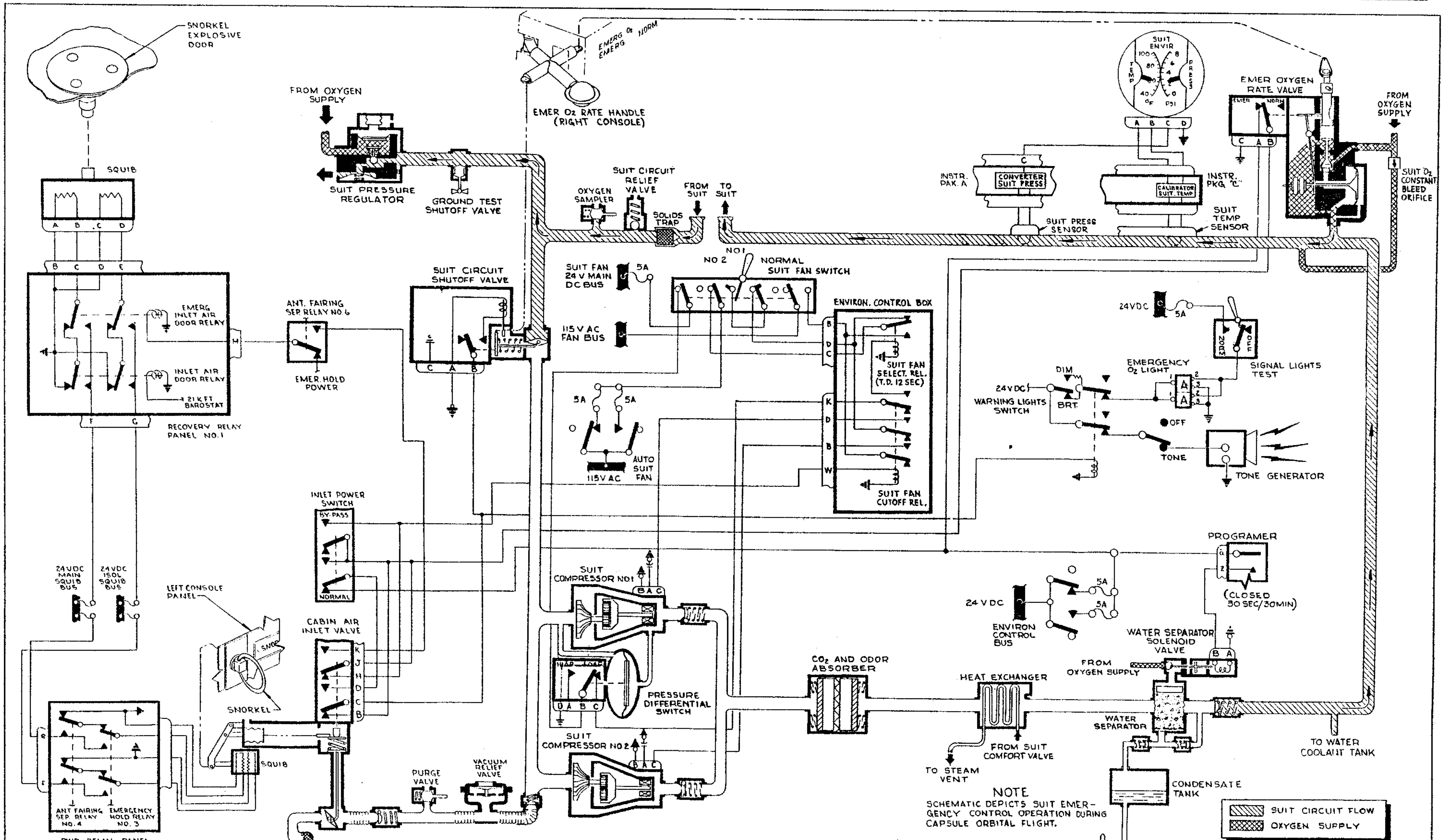


FIGURE 3-5 SUIT EMERGENCY CONTROL

PM45-30D

coated nylon closure coupling. The closure coupling is attached to the ends of the suit environmental control system inlet and outlet ducts.

The suit circuit incorporates two compressors that are installed parallel to each other. During normal suit circuit operation the #1 suit compressor circulates the suit oxygen from the pressure suit outlet, throughout the suit circuit. A differential pressure switch is vented to the inlet and outlet ducting of the #1 suit compressor. In the event the #1 suit compressor malfunctions, or fails to operate, the differential switch senses the pressure drop across the #1 suit compressor, and in turn directs power to operate the #2 suit compressor. A SUIT FAN switch is provided on the main instrument panel, to enable selection of either compressor. Oxygen flowing from the compressors passes through the CO_2 and odor absorber. The absorber is divided into individual sections that contain activated charcoal and lithium hydroxide removing odors and carbon dioxide from the oxygen, to prevent any discomfort to the Astronaut. Filters, incorporated in the absorber, remove charcoal or lithium hydroxide dust from entering the suit circuit oxygen.

Suit circuit temperature is controlled by a suit heat exchanger, that removes heat from the suit circuit oxygen flowing through the heat exchanger. Waterflow to the heat exchanger is controlled by a suit temperature control valve, located on the right console. Suit circuit oxygen pressure is also utilized to pressurize the water coolant tank in the event the coolant quantity oxygen bottle, normally utilized to pressurize the water tank, malfunctioned. Suit pressure and temperature sensors, located in the suit circuit, transmit suit circuit pressure and temperature to the SUIT ENVIRONMENT indicator. The SUIT ENVIRONMENT indicator, located on the main panel, is a dual face indicator and indicates SUIT PRESS and SUIT TEMP. The water separator is a filter-type sponge, that collects moisture from the suit circuit oxygen flowing through the

separator. At timed intervals, the sponge is pneumatically compressed to remove the water from it. Water removed from the sponge is drained into a condensate storage tank, located adjacent to the water separator. The sponge is compressed by a piston that is actuated by oxygen pressure. The capsule programmer provides 24V D-C electrical power to energize the water separator solenoid valve for 30 seconds every 30 minutes. Energizing the solenoid valve, opens the valve to allow oxygen pressure (100 psi) to actuate the water separator piston. The water separator piston incorporates two magnets. The magnets aid in determining the position of the piston before and after actuation. Oxygen, flowing through the water separator, flows to the closed emergency oxygen rate valve and through the Astronaut's pressure suit. Oxygen, from the pressure suit, then passes through a solids trap, that is provided to remove any foreign matter such as food particles, hair, nasal excretions, etc., from the suit circuit oxygen supply. The solids trap incorporates a relief feature, to prevent the possibility of foreign matter blocking suit circuit flow. The suit circuit shutoff valve, located downstream of the solids trap, is mechanically locked in the open position during operation in the suit environmental control mode.

During capsule pre-launch phase, the suit circuit is purged and saturated with oxygen from an external low pressure source. Suit heat exchanger is also supplied with a freon coolant, from an external ground supply, to provide suit circuit cooling. The suit circuit oxygen circulates throughout the suit circuit, during the suit environmental control mode operation. During capsule flight the pressure within the suit circuit is automatically maintained at approximately 5 psia by the pressure regulator. During the landing phase, the capsule 21,000 feet barostats close at a capsule altitude of approximately 21,000 feet. Closing of the 21,000 feet barostats directs 24V D-C electrical power to energize the inlet air door relay. Energizing the inlet air door relay directs power to ignite an explosive squib, which in turn ejects the snorkel explosive door. (Door is located on capsule exterior.) When the capsule cabin descends to an altitude of 17,000 ± 3000 feet, the cabin air inlet and outflow valves open barometrically. The suit compressor draws atmospheric air into the suit circuit through the ejected snorkel door opening, the snorkel valve and the open cabin air inlet valve. In the event the cabin air inlet and outflow valves fail to open, the Astronaut may manually open the valves by actuating the SNORKEL pull ring, located on the left console. If the Astronaut does not open the valves manually, the valves will open automatically at 10,000 feet when the antenna fairing is ejected. Ejection of the antenna fairing directs electrical power to ignite the cabin air inlet and outflow valves explosive squibs, which in turn mechanically open the valves. Opening of the cabin air inlet valve automatically switches the environmental system mode of operation to the suit emergency mode, but the suit circuit compressor continues to operate to provide suit circuit ventilation. Also, opening of the cabin air inlet valve directs electrical power to close the suit circuit shutoff valve, which in turn mechanically opens the emergency oxygen rate valve and provides electrical power to illuminate the O_2 EMER light and operate a tone generator. Electrical power is also provided to energize the emergency air inlet door relay, which in turn directs electrical power to ignite the snorkel explosive door squib and eject the snorkel explosive door. (This provision insures the ejection of the snorkel explosive door, in the event the door failed to eject at 21,000 feet.) Air circulating through the suit circuit is vented through the suit pressure regulator to the cabin, and in turn is vented out of the capsule through the cabin outflow valve. During the capsule post-landing phase, ventilation is provided by operating the suit circuit compressor, which in turn draws outside air in through the cabin air inlet valve and vents cabin air out the cabin outflow valve. In the event the capsule submerges momentarily, following a water landing, the ball float in the cabin air inlet valve and the diaphragm flapper valves in the cabin air outflow valve will seat. Seating of the valves (snorkel and flapper), prevents water from entering into the suit circuit and cabin, through the open cabin air inlet and outflow valves. Operation of the suit circuit compressor with the snorkel valve closed will create a vacuum in the flexible ducting, located between the cabin air inlet valve and the suit circuit. The vacuum relief valve, located in the flexible ducting, will open when the pressure differential between the cabin and flexible ducting is 10-15 inches of water. Opening of the vacuum relief valve allows cabin pressure to enter into the suit circuit flexible air inlet ducting, and unseat the air inlet snorkel valve ball float, if the capsule snorkel valve is above the water. This action in turn allows outside air to enter into the suit circuit to continue ventilation. During capsule submersion, cabin air entering the open vacuum relief valve provides suit circuit ventilation.

3-10. SUIT EMERGENCY CONTROL

The suit emergency control, Figure 3-5, is provided to insure Astronaut's survival in the event the cabin and suit environmental control circuits malfunction. Operation in the suit emergency control mode basically consists of opening the emergency oxygen rate valve, to supply oxygen at a rate greater than normal; and closing of the suit circuit shutoff valve, which in turn eliminates oxygen flow through the temperature control and impurity removing units. Illumination of the O_2 EMERG light and the movement of the EMERG O_2 rate handle to EMERG position, indicates environmental system operation in the suit emergency control mode.

When operating in the suit environmental control mode, during capsule normal orbital flight, the emergency oxygen rate valve is closed, the suit circuit shutoff valve is open, suit compressors are operative, and the suit circuit pressure regulator is controlling oxygen flow to the suit circuit. The emergency oxygen rate valve remains closed as long as suit circuit pressure remains at approximately 5 psia pressure. In the event the suit circuit pressure drops to $4.0 \begin{smallmatrix} + .1 \\ - .3 \end{smallmatrix}$ psia, the rate valve internal aneriod extends, to offseat a poppet, and allows oxygen from the oxygen supply to flow through the rate valve and into the suit circuit. The extension of the rate valve aneriod, due to low pressure, actuates a limit switch that provides electrical power to energize the suit circuit shutoff valve solenoid and the suit fan cut-off relay, illuminate the O_2 EMERG light, and operate a tone generator. Energizing the suit fan cut-off relay removes the 115V A-C electrical power to operate the suit circuit compressor. (At an altitude of 17,000 $\pm$ 3000 feet, the cabin air inlet relay will open. Opening of the cabin air inlet relay de-energizes the suit fan cutoff relay. The de-energized suit fan cutoff relay routes power to the #1 suit circuit compressor. If the #1 suit circuit compressor fails to operate within 12 seconds, the suit fan selector relay will energize and allow power to be directed to the suit fan cutoff relay and then on to the #2 suit circuit compressor.) Energizing the shutoff valve solenoid releases the shutoff valve shaft arm, and mechanically moves the EMERG O_2 handle, right console, to the EMERG position. Movement of the EMERG O_2 handle moves a cable, that is connected to the emergency oxygen rate valve shaft arm, and mechanically actuates the emergency rate valve to maintain the rate valve in the open position. With the emergency oxygen rate valve open and the suit circuit shutoff valve closed, oxygen from the oxygen supply flows into the pressure suit and is discharged through the suit pressure regulator relief valve.

Actuating the EMERG O_2 handle to the NORM position resets the shutoff valve to the open position, the emergency oxygen rate valve to the close position, starts suit compressor operation, extinguishes the O_2 EMERG light, and in turn switches the suit circuit operation to the suit environmental control mode. The suit emergency mode is also automatically selected during capsule landing phase, when the capsule has descended to an altitude of 17,000 ± 3000 feet. At 17,000 ± 3000 feet the cabin air inlet valve opens. Opening of the cabin air inlet valve actuates a limit switch that provides electrical power to operate the suit circuit compressor and close the shutoff valve, which in turn mechanically opens the emergency oxygen rate valve. An inlet power switch, located on the main instrument panel to the right of the satellite clock, is incorporated in the environment control system. The inlet power switch allows operation in the suit environmental control mode in the event the cabin air inlet valve prematurely opens (See Figure 3-4). Premature opening of the cabin air inlet valve deactivates the cabin fan and closes the suit circuit shutoff valve which in turn opens the emergency oxygen rate valve. The suit circuit is now operating in the emergency mode. To initiate transition back to the suit environmental control mode, the inlet power switch is placed in the BY-PASS position. With the inlet power switch in the BY-PASS position, the cabin fan is activated (See Figure 3-3) and the suit circuit shutoff valve is deactivated. The EMER O_2 handle, right hand console, is now placed in the NORM position; placing of the EMER O_2 handle to the NORM position opens the suit circuit shutoff valve which in turn closes the emergency oxygen rate valve. The environmental control system is now operating in the suit environmental control mode. To prevent snorkel door separation upon premature opening of the cabin air inlet valve, the emergency inlet air door relay is interconnected to the antenna fairing separation relay during descent. After opening of the cabin air inlet and outflow valves, the inlet power switch is placed in the NORMAL position.

3-11. OXYGEN SUPPLY

During the capsule pre-launch phase and prior to installation of the capsule entrance hatch, the capsule oxygen supply shutoff valves are manually opened, by ground crewmen, to activate the oxygen supply. Opening of the primary and secondary oxygen supply shutoff valves, Figure 3-6, provides oxygen to the cabin pressure control valve, suit pressure regulator, suit emergency oxygen rate valve, constant bleed orifice which routes oxygen directly to the suit circuit inlet duct and the suit circuit water separator solenoid valve.

During operation, when the primary oxygen bottle pressure drops below approximately 200 psig, due to near depletion of the primary oxygen supply; the secondary oxygen supply line pressure will override the primary oxygen supply line pressure and continue to supply the environmental system with oxygen. Two oxygen flow sensors, one located in the primary oxygen supply line and one located in the secondary oxygen supply line, detect environmental control system transition from primary oxygen supply to secondary oxygen supply. Used in conjunction with the oxygen flow sensors is an oxygen flow switch (See Figure 3-6). The oxygen flow switch, located on the main instrument panel to the right of the satellite clock, is a two position switch marked "SEC" and "PRIM". When the primary oxygen supply flow rate drops to approximately zero pounds per minute at 80 psig, the oxygen flow sensor will direct a 24 volt d-c signal to illuminate the O_2 QUAN light and operate the tone generator. The O_2 QUAN light, located on the main instrument panel, and the tone generator are provided to indicate to the Astronaut that the secondary oxygen supply is being utilized. The O_2 flow switch should now be positioned to the "SEC" position. Positioning the O_2 flow switch to "SEC" removes the 24 volt d-c signal from the O_2 QUAN light and tone generator circuits. A quantity indicator gage, located on the main instrument panel, is provided to indicate remaining oxygen supply. Two transducers, primary and secondary supply, are provided to enable telemetering of oxygen quantity remaining.

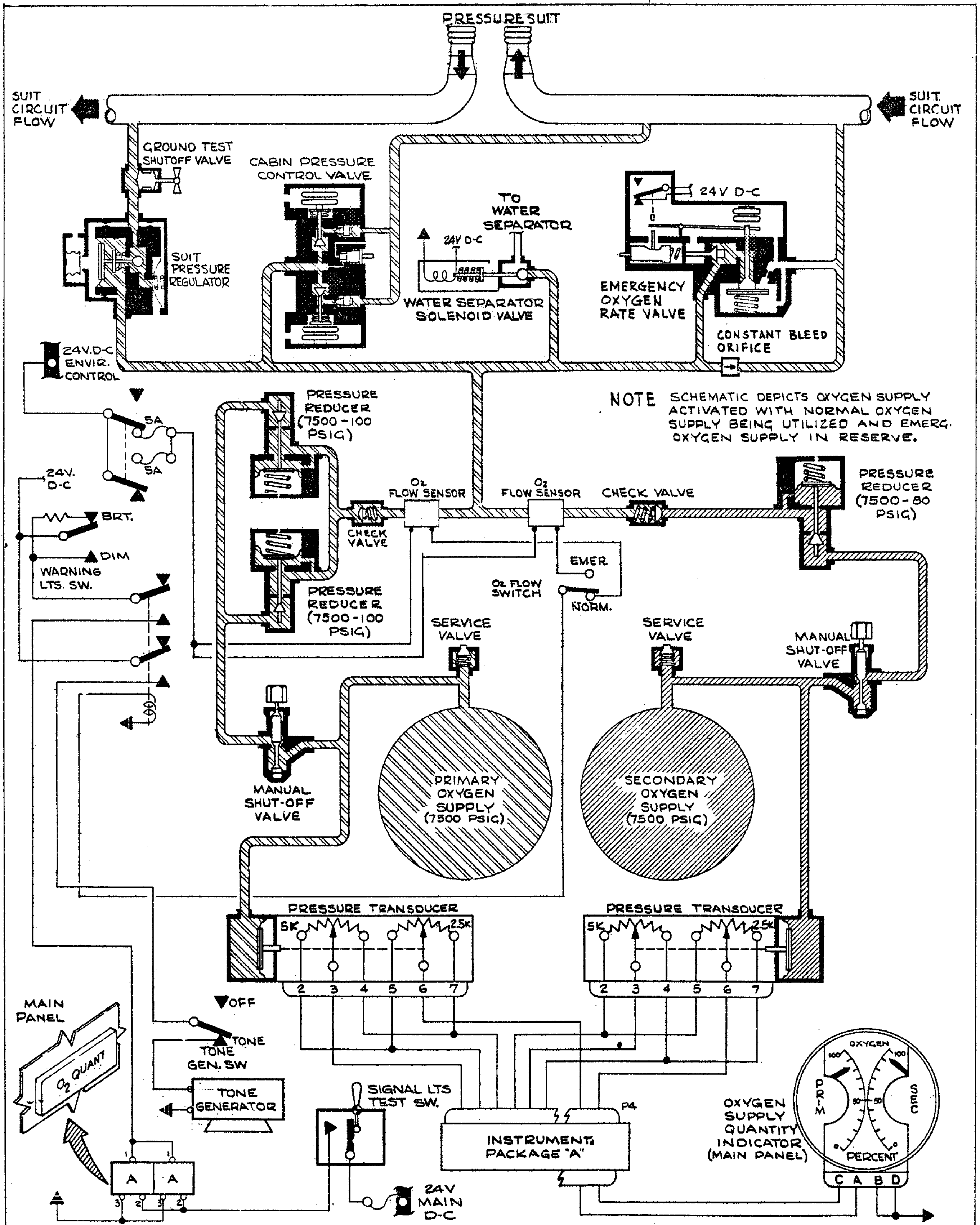


FIGURE 3-6 PRIMARY AND SECONDARY OXYGEN SUPPLY

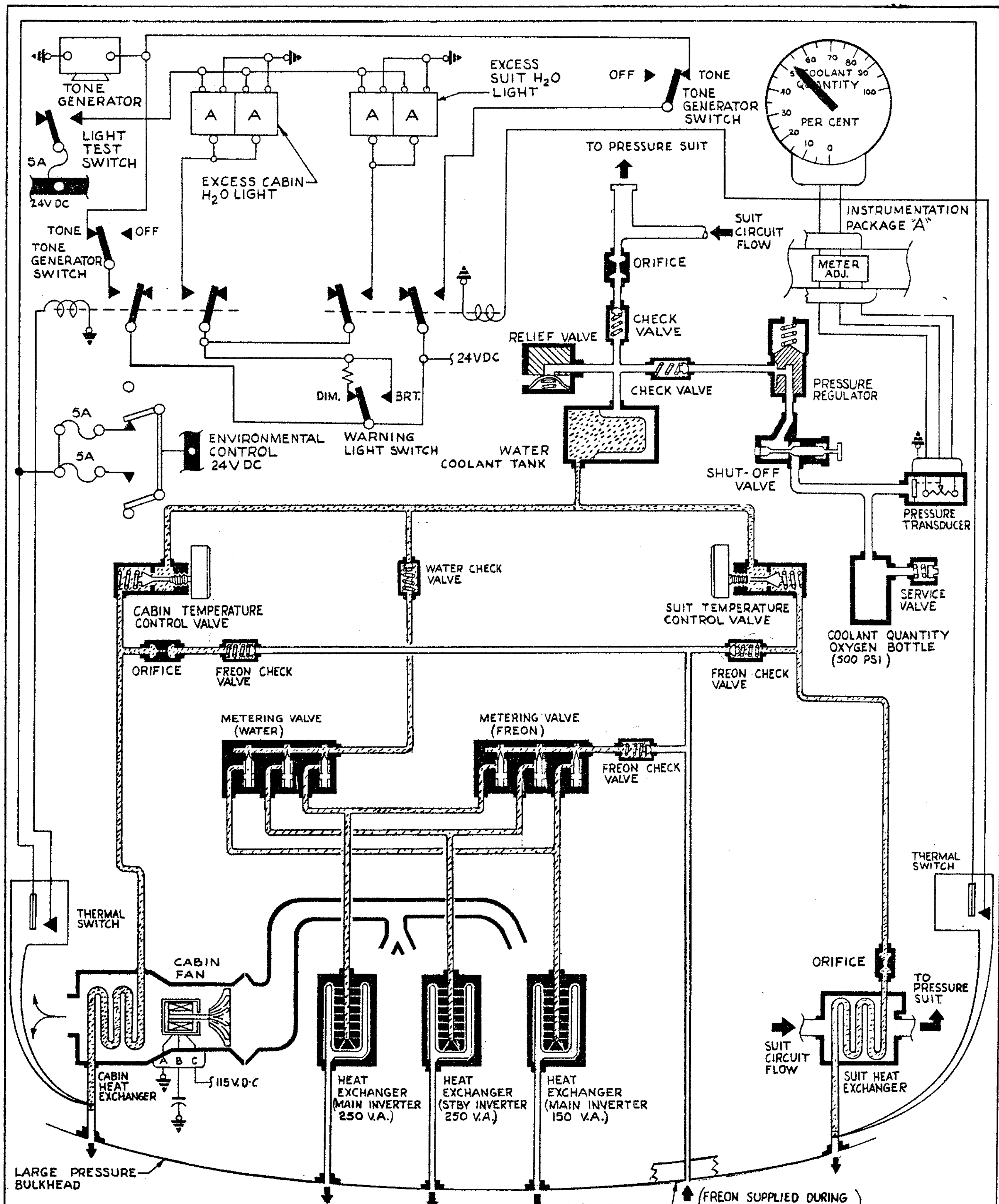
PM45-31D

3-12. COOLING CIRCUIT

The cooling circuit, Figure 3-7, basically consists of a water coolant tank, cabin and suit temperature control valves, cabin and suit heat exchangers, inverter heat exchangers, coolant quantity indication circuit, and an excessive water warning circuit. During capsule pre-launch, after the entrance hatch has been installed, cabin, suit circuit and inverter cooling is achieved by supplying freon (F-114) through the capsule umbilical connector and into the cabin, suit and inverter heat exchangers. The freon coolant absorbs heat from the cabin and suit air flowing through the heat exchangers, and boils overboard through the environmental system steam vents, located in the large pressure bulkhead. Freon metered to three inverter heat exchangers absorbs and dissipates heat from the inverters in the same manner as the cabin and suit circuit heat exchangers. Forty-five seconds prior to capsule launching, the freon coolant supply is discontinued. When the capsule reaches approximately 115,000 feet altitude, inverter, cabin and suit circuit cooling is achieved by water evaporation, that occurs within the inverter, suit and cabin heat exchangers. The coolant quantity indicating system pressure relief valve remains open, during capsule launch, until the pressure decreases to approximately 5.9 psia. The relief valve closes at 5.9 psia pressure and in turn enables the coolant quantity indicating system to operate.

Water from the water coolant tank is supplied, under a 5.5 psia pressure, through the temperature control valves, to the suit and cabin heat exchangers. Water is also supplied and metered to the main and standby inverter heat exchangers. Oxygen, stored under a 500 psig pressure in the coolant quantity oxygen bottle, is utilized to pressurize the water coolant tank. A pressure regulator decreases the coolant oxygen supply 500 psig pressure to 5.5 psia pressure. A cooling circuit pressure relief valve relieves cooling circuit pressures in excess of approximately 6 psia. Oxygen pressure within the water coolant tank tends to move the tank diaphragm, which in turn forces the water supply out of the tank at a rate dependent upon the position of the temperature control valves. In the event the coolant quantity oxygen supply should deplete or malfunction, oxygen, at 5 psia pressure from the suit circuit, will continue to pressurize the water coolant tank. The temperature control valves control the amount of water entering the heat exchangers, and in turn controls cabin and suit temperatures. Water within the heat exchangers absorbs heat from the cabin and suit oxygen, flowing through the heat exchangers. The heated water evaporates and flows out through the steam vents, located in the large pressure bulkhead. Water metered to three inverter heat exchangers absorbs and dissipates heat from the inverters in the same manner as the cabin and suit circuit heat exchangers. In addition, heat generated by the inverters is drawn into the cabin heat exchangers by means of the cabin fan. Indicator lights are provided on the main instrument panel to indicate extreme cold conditions in the cabin and suit heat exchangers exhaust ducts, which could possibly freeze and plug overboard steam vents. If the heat exchangers exhaust ducts temperatures drop below 42°F, a thermal switch, located in each of the exhaust ducts actuates close. Closing of either thermal switch directs 24V D-C electrical power to illuminate either the EXCESS CABIN H_2O or the EXCESS SUIT H_2O light, and operate the tone generator; thus indicating to the Astronaut of extreme cold temperatures in the heat exchangers exhaust ducts. The Astronaut must then position the cabin or suit temperature control valve to a warmer setting, in order to reduce the possibility of water freezing in the exhaust duct.

A coolant quantity indicator, main instrument panel, is provided to indicate the quantity of water coolant remaining in the water coolant tank. The indicator operates in direct relationship to the oxygen remaining in the coolant quantity



NOTE
SCHEMATIC DEPICTS COOLING CIRCUIT OPERATION DURING NORMAL CAPSULE FLIGHT

FIGURE 3-7 COOLING CIRCUIT

PM45-36B

oxygen bottle, through a pressure transducer and instrumentation package. When the coolant quantity oxygen bottle is full, (500 psi), the coolant quantity indicator will read 100%. As the coolant oxygen bottle pressure decreases, as a result of water being utilized, the coolant quantity indicator reading will decrease accordingly.

3-13. SYSTEM UNITS

3-14. PRIMARY AND SECONDARY OXYGEN BOTTLES

The primary and secondary spherical shaped oxygen bottles are located beneath the Astronaut's support couch adjacent to the capsule conical section and large pressure bulkhead. Each bottle has a capacity of 4 pounds oxygen, stored under a 7500 psig pressure at 70°F temperature. Reduction of pressure for utilization in the environmental control system is accomplished with pressure reducers. The primary supply is reduced to approximately 100 psig; the secondary oxygen supply is reduced to approximately 80 psig. Servicing of the oxygen bottles is accomplished through a quick disconnect filler coupling.

3-15. SUIT CIRCUIT PRESSURE REGULATOR

The suit circuit pressure regulator, Figure 3-8, is provided to regulate oxygen pressure to the suit circuit and to replenish suit circuit oxygen consumed by the Astronaut, absorbed by moisture or carbon dioxide or lost through leakage. The regulator is a demand type diaphragm operated regulator that controls suit circuit pressure in reference to cabin pressure. Suit circuit pressure is maintained approximately 2.5 - 3.5 inches of water below cabin pressure during normal system operation, under ideal (no cabin leakage) conditions. Cabin pressure is sensed on the upper side of the regulator control diaphragm and suit circuit pressure is sensed on the lower side of the diaphragm. The regulator also contains a resilient type diaphragm that is used to relieve excessive suit circuit pressures. Two aneroids are provided to shut off cabin vent port of regulator in the event cabin pressure decreases below 4.6 + .2 psia. In the event of cabin leakage, not decreasing below $4.0 {+.2 \atop -.1}$ psia, the cabin pressure control valve will open to replenish cabin pressure to $5.1 {+.2 \atop -.1}$ psia. Make up oxygen from the cabin pressure control valve will flow through the suit circuit and out through the suit pressure regulator relief valve and into the cabin. At this time, suit circuit pressures will exceed cabin pressures due to pressure differential (suit above cabin) required to open the suit circuit pressure regulator relief valve. The cabin leakage rate will determine the amount the suit circuit pressures will exceed the cabin pressures.

During normal capsule ascent, cabin pressure decreases, and the regulator relief diaphragm relieves suit circuit pressure to within 2 - 9 inches H_2O above cabin pressure. During capsule normal orbital flight, the control diaphragm will regulate suit circuit pressure in relationship to cabin pressure. An increase in cabin pressure will act on the diaphragm to offseat a poppet valve and allow suit circuit pressure to increase to within 2.5 - 3.5 inches of H_2O below cabin pressure. In the event cabin pressure decreases below 4.6 ± .2 psia, the aneroids will extend and close off cabin vent port of regulator. Two 60 cc/min bleed ports will then bypass the poppet valve to the cabin sensing side of the control diaphragm and regulate suit circuit pressure to 4.6 ± .2 psia. Two aneroids and two bleed ports are provided to insure regulator operation, in the event either aneroid or either bleed port fails to function. Descent operation of the regulator is the same as an increase in cabin pressure during capsule normal orbital flight.

3-16. SUIT CIRCUIT SHUTOFF VALVE

The suit circuit shutoff valve, Figure 3-9, is designed to shut off oxygen

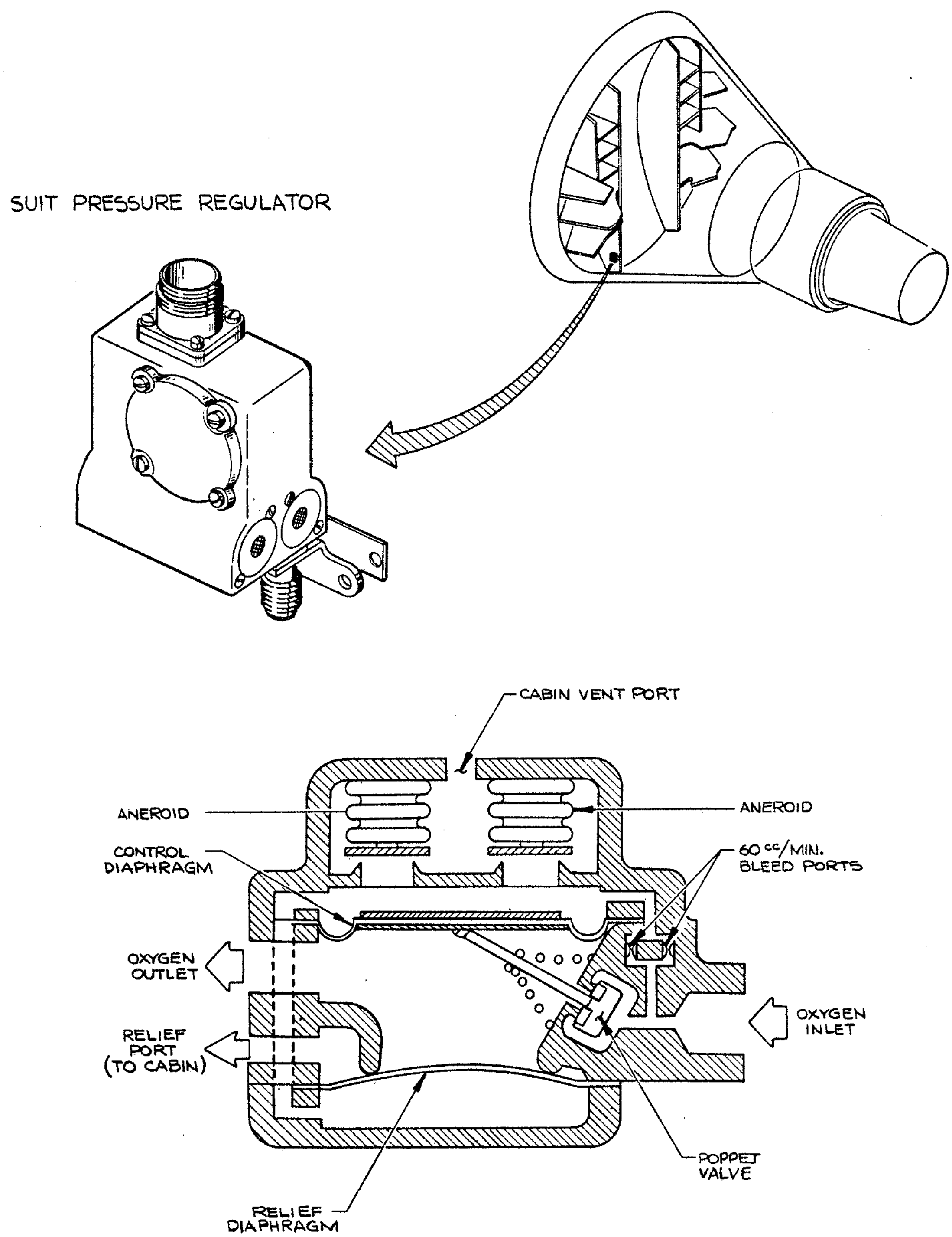


FIGURE 3-8 SUIT PRESSURE REGULATOR

PM45-159 B

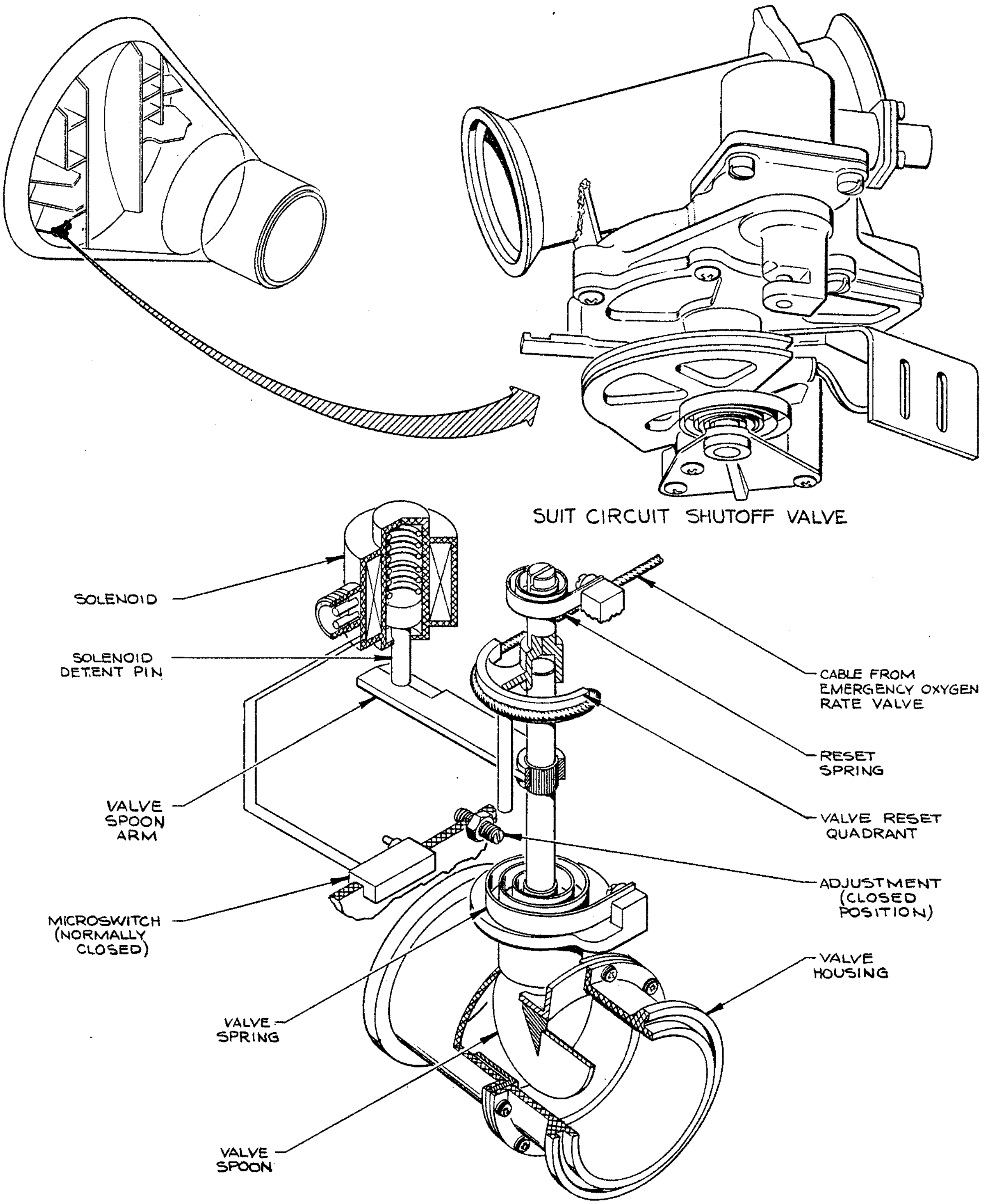


FIGURE 3-9 SUIT CIRCUIT SHUTOFF VALVE

PM45-152 A

flow to the suit environmental circuit accessory components, whenever the suit circuit is operating in the emergency mode. Closing of the suit circuit shutoff valve reserves the remaining oxygen supply for the Astronaut's pressure suit. The shutoff valve, spring loaded to the close position, is latched in the open position during normal suit circuit operation. Valve is maintained in the open position by a solenoid controlled detent pin engaged into the valve spoon arm. A micro switch, depressed by the valve arm, completes the solenoid circuit when the valve is latched open. Opening of either the emergency oxygen rate valve or the cabin air inlet valve directs an electrical signal to energize the shut-off valve solenoid. Energizing the solenoid retracts the detent pin and allows the valve spring to rotate the valve spoon to the close position. Closing of the valve opens the solenoid circuit and opens the emergency oxygen rate valve, through an inter-connecting cable. The shutoff valve is mechanically opened by the EMER O_2 control handle, located in capsule. The shutoff valve is inter-connected to the emergency rate valve, so that when the emergency rate valve closes, the shutoff valve opens.

3-17. EMERGENCY OXYGEN RATE VALVE

The emergency oxygen rate valve, Figure 3-10, is provided to supply a regulated amount of oxygen directly into the Astronaut's pressure suit, in the event malfunction occurs in the suit circuit operation. The rate valve is designed to operate automatically and contains provisions for manual operation. The valve, closed during normal suit circuit operation, contains an aneroid that senses suit circuit pressure. Whenever suit circuit pressure drops below 4.0 $^{+.1}_{-.3}$ psia, the aneroid extends to offseat a spring loaded poppet and allow oxygen pressure to enter the diaphragm chamber. The pressure in the diaphragm chamber increases and fully strokes the poppet, allowing oxygen to flow into the Astronaut's suit at a fixed flow of .049 to .051 #/min. Simultaneously with the

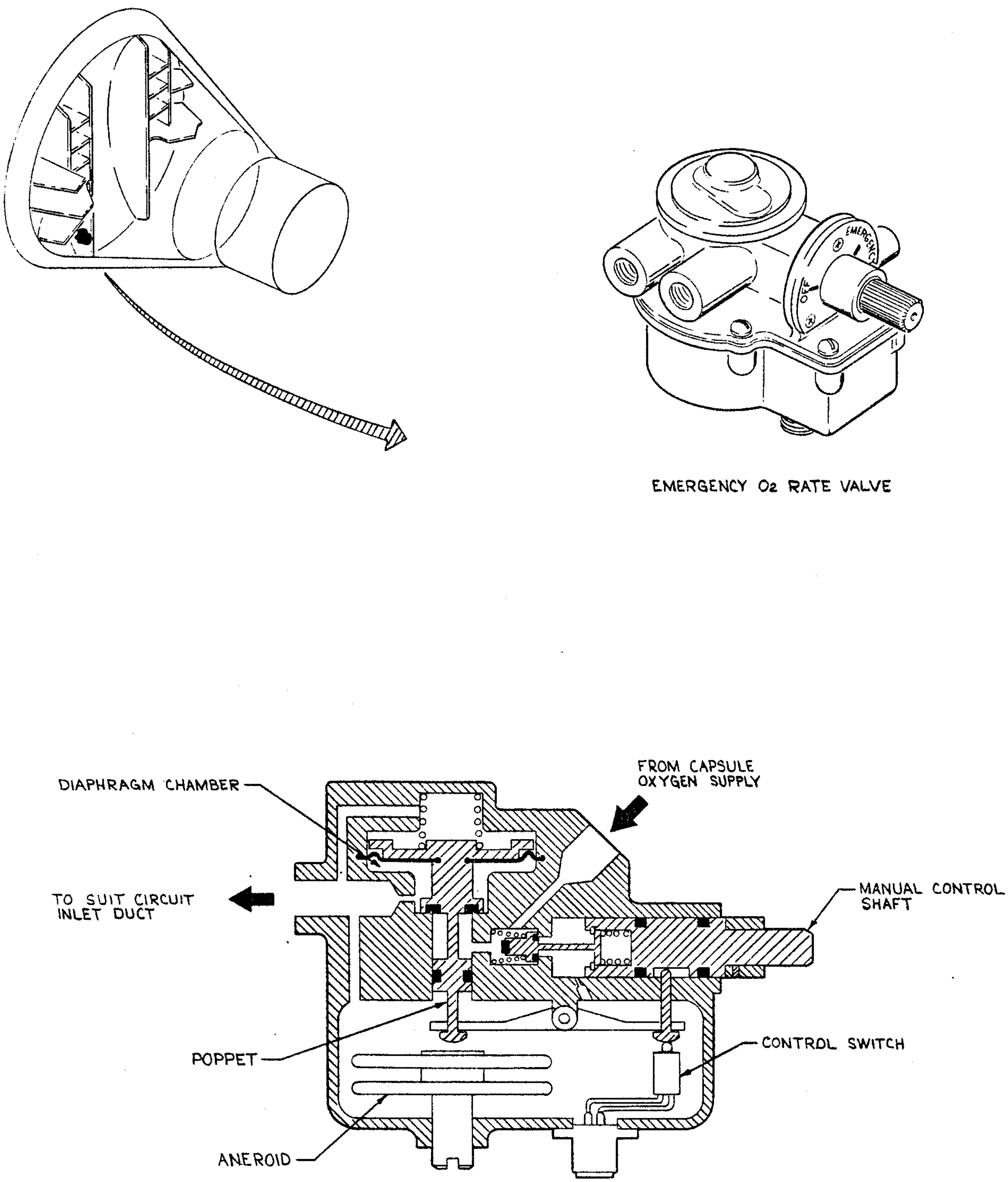


FIGURE 3-10 EMERGENCY O_2 RATE VALVE

PM45-153 A

offseating of the poppet, a control switch is actuated through a lever mechanism, and directs electrical power to close the suit circuit shutoff valve, illuminate the O_2 EMERG light, and stop suit circuit compressor operation during capsule orbital flight. Suit circuit shutoff valve is interconnected with emergency oxygen rate valve. Therefore, closing of the shutoff valve actuates the emergency oxygen rate valve manual control shaft to close off oxygen flow to valve poppet inlet. Oxygen then flows directly into suit circuit through the valve aneroid chamber.

Emergency rate valve control shaft actuation actuates a pin to depress control switch and also moves EMERG O_2 control handle (right console) to EMERG position. Emergency oxygen rate valve may be opened manually by selecting EMER position with EMERG O_2 control handle. Operation will be same as control shaft arm operation, described above. Whenever the EMER O_2 control handle is moved to NORM, the suit circuit shutoff valve opens and emergency oxygen rate valve closes.

3-18. SUIT CIRCUIT COMPRESSORS

The suit circuit environmental control system utilizes two electric motor driven, single-stage, centrifugal compressors (See Figure 3-4). One compressor is for the normal circulation of gases within the suit circuit; the other is a standby compressor used in the event of normal compressor failure. If the normal compressor fails, the standby compressor is activated by a pressure differential switch which directs power to the standby compressor electrical connections. The only time the suit compressor is inoperative is during orbital flight when the Astronaut is utilizing oxygen from the emergency oxygen rate valve. When supplementary oxygen from the emergency oxygen rate valve is being used below 20,000 feet, the suit circuit compressor will continue to operate to circulate ambient air to the Astronaut.

3-19. CO_2 AND ODOR ABSORBER

The CO_2 and odor absorber, Figure 3-11, is provided to remove Astronaut emitted odors and carbon dioxide from the suit circuit. The absorber is basically a metal cannister divided into two sections. The inlet section contains activated charcoal that removes objectional odors from the suit circuit oxygen. Lithium hydroxide, located in the center sections removes carbon dioxide. The outlet section is an exit filter, provided to prevent charcoal and lithium hydroxide dust from entering the suit circuit oxygen flow. The charcoal and lithium hydroxide granules are compressed by a spring force. The CO_2 and odor absorber has an operating life of approximately 31 hours, and to insure proper absorber operation the absorber should be replaced prior to capsule mission.

3-20. SUIT CIRCUIT HEAT EXCHANGER

The suit circuit heat exchanger (Figure 3-12) is of a plate fin construction with rectangular offset fins, double sandwich, one pass on the oxygen side and two pass, single sandwich on the water side. The function of the heat exchanger is to cool the gases circulating throughout the suit circuit. Water from the water cooling tank is routed to the inlet side of the heat exchanger at which point it is directed to a high density woven felt pad. The function of the felt pad is to evenly distribute the water through the heat exchanger. As water passes through the felt pad, it comes into contact with the heat transfer surfaces on the water side of the heat exchanger. The water then absorbs the heat from the circulating gases and the water is then boiled off as steam and dumped overboard.

3-21. WATER SEPARATOR

The water separator, Figure 3-13, is provided to remove moisture, condensed as a result of suit heat exchanger operation, from the suit circuit oxygen. The

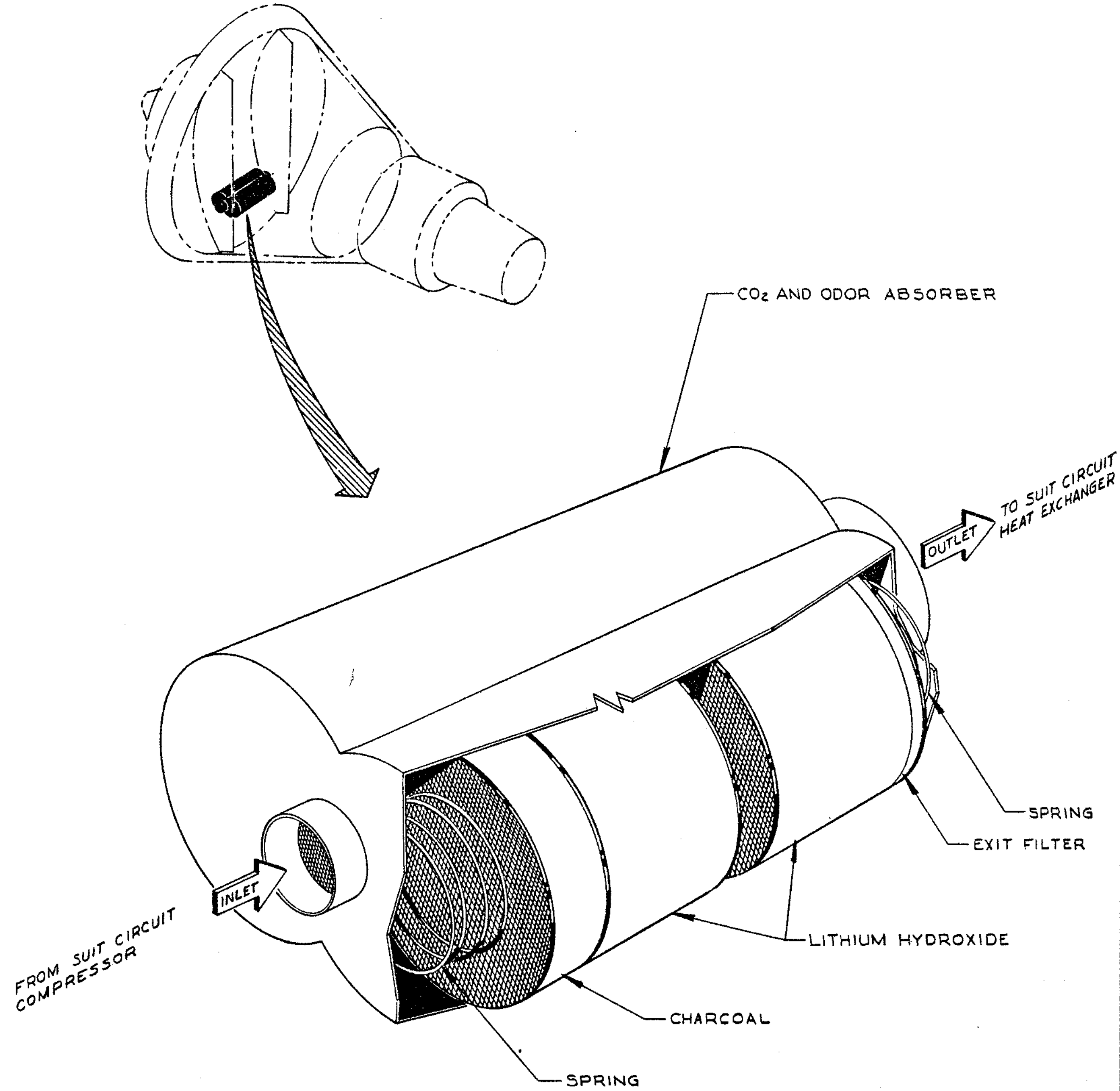


FIGURE 3-11 CO_2 AND ODOR ABSORBER

PM45-156A

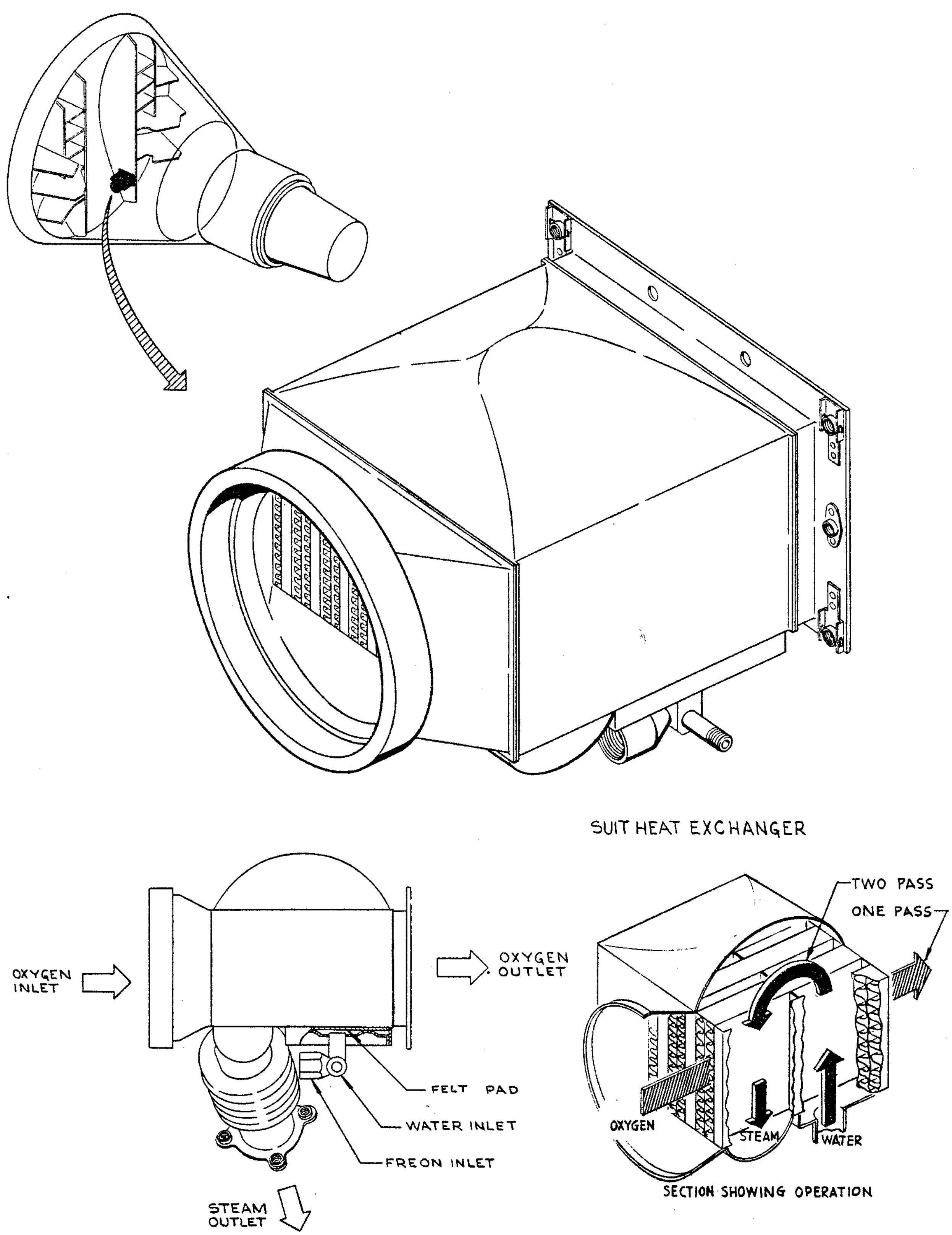


FIGURE 3-12 SUIT HEAT EXCHANGER

PM45-236

separator is basically a filter type sponge that collects moisture from the oxygen passing through it. The sponge, pneumatically compressed, removes the condensate from the sponge and deposits it into a storage tank. During suit circuit operation, the sponge filters moisture from the oxygen flowing through the sponge. Once every 30 minutes, for a duration of 30 seconds, the capsule programmer supplies electrical power to energize the water separator solenoid valve. Energizing the normally closed solenoid valve opens the valve and directs oxygen from either the primary or secondary supply to the piston stem and the piston plate chambers.

Due to the difference in area, on each side of piston, the piston raises the sponge out of the suit circuit oxygen flow and is compressed against the separator housing plate. Water squeezed out of the sponge drains into the condensate tank. Following the termination of squeezing (30 seconds), the water separator solenoid valve is de-energized and the solenoid valve closes. Oxygen below the separator piston is vented to cabin through the separator solenoid valve. Oxygen above the piston, entrapped by a check valve, forces the piston down, thus returning the sponge into suit circuit oxygen flow. Suit circuit pressure is also supplied to top of separator to aid in forcing the sponge down. Two check valves, located on top of separator, prevent water from entering the suit circuit and also prevents water backflow into the top of separator. A check valve is supplied to prevent oxygen depletion in the event separator mechanisms developed a leak. During squeezing operation suit circuit oxygen flow will not be affected, as oxygen will continue to flow through area normally occupied by the sponge. The water separator piston incorporates two magnets. The magnets aid in determining the position of the piston before and after actuation.

3-22. SOLIDS TRAP

The suit circuit solids trap, Figure 3-14, is located in the pilot's suit

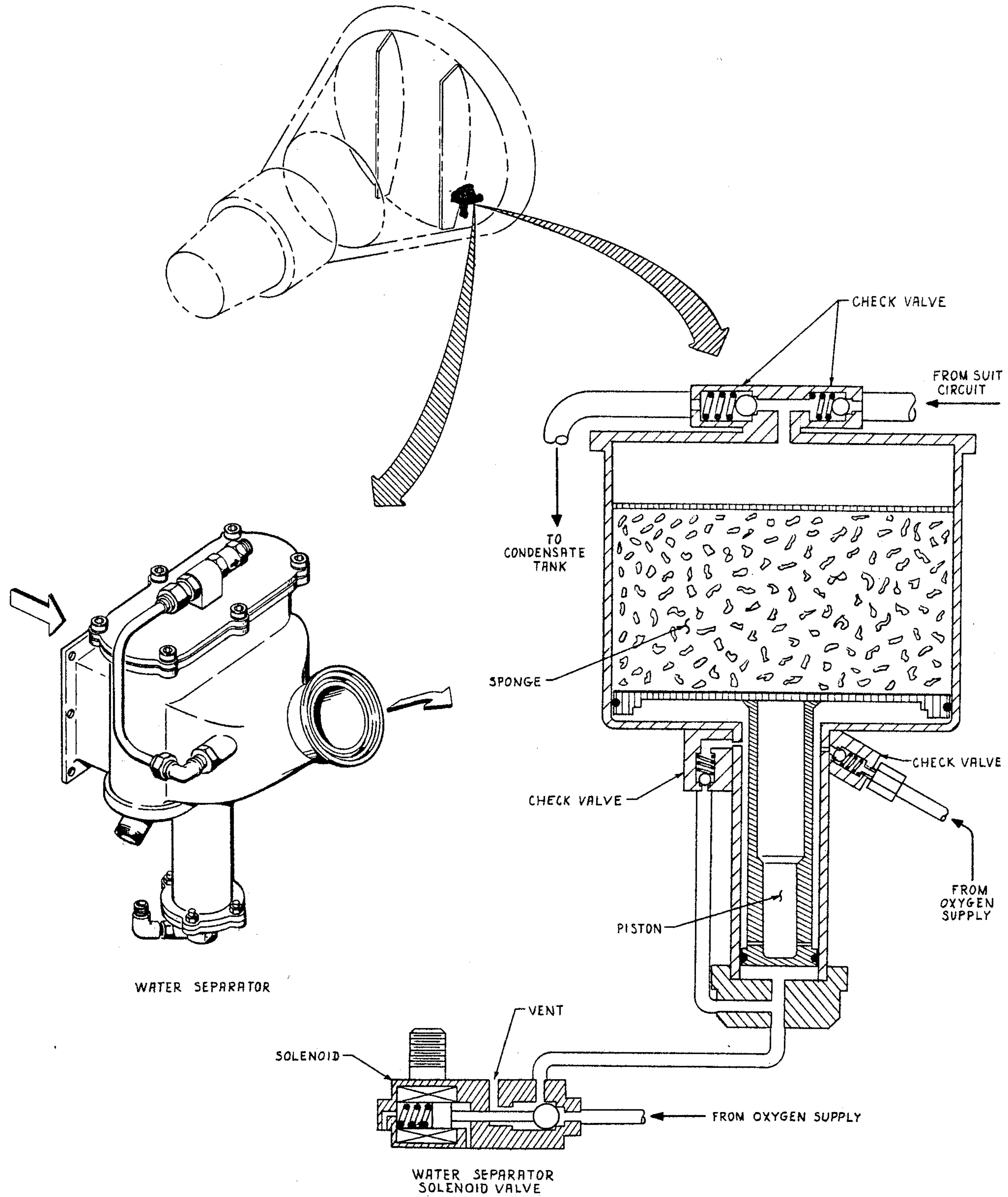


FIGURE 3-13 WATER SEPARATOR

PM45-157B

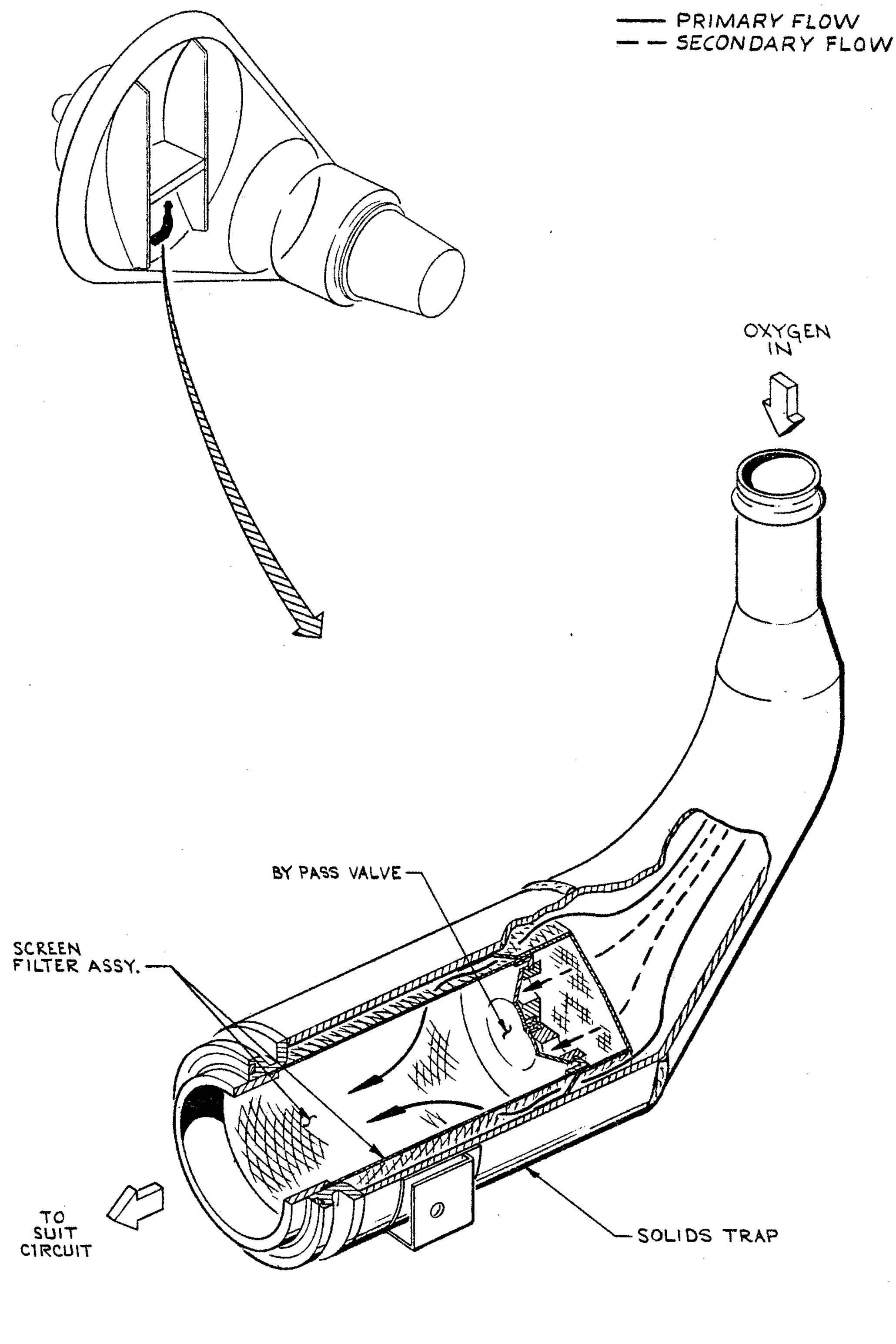


FIGURE 3-14 SUIT CIRCUIT SOLIDS TRAP

PM45-231A

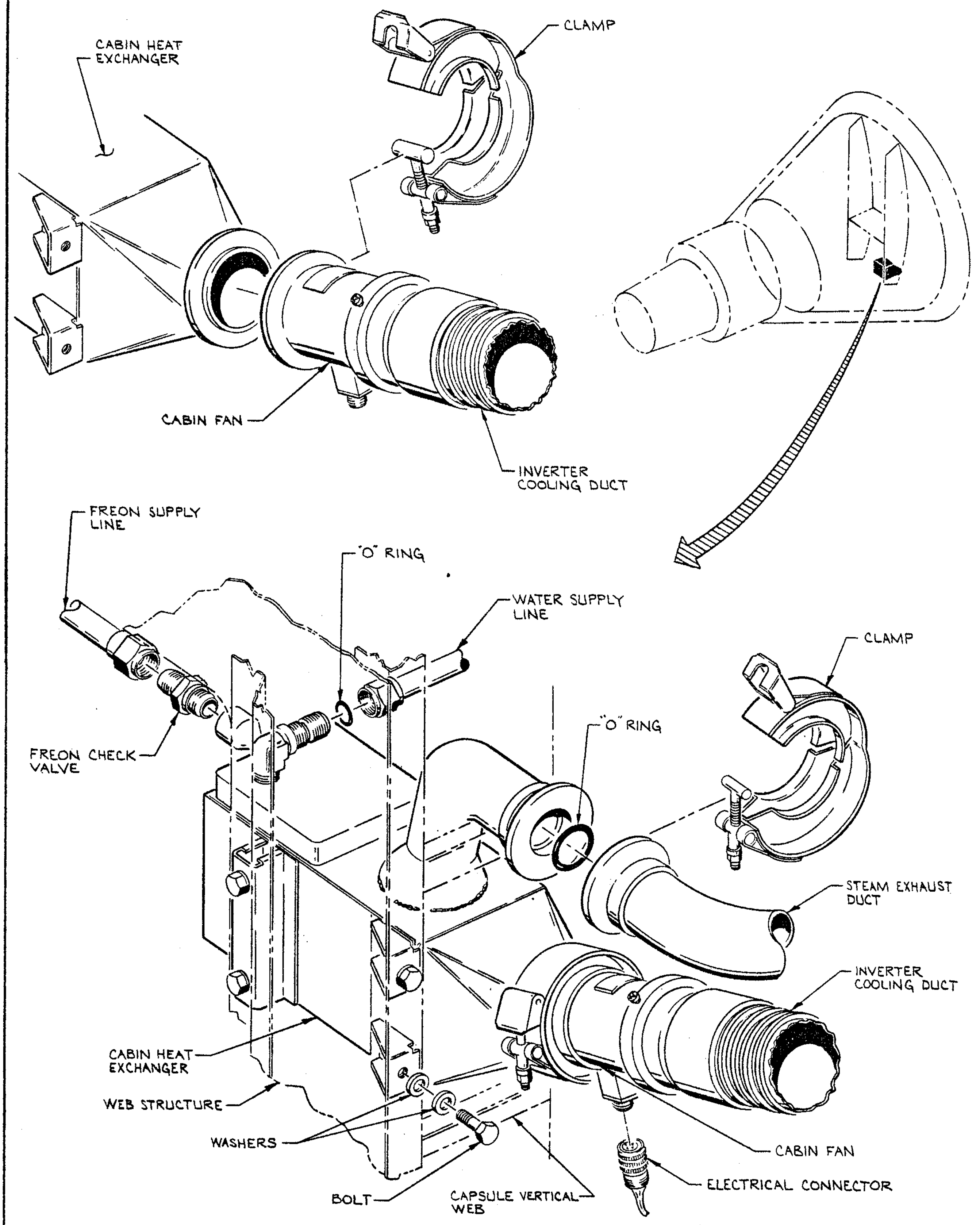


FIGURE 3-15 CABIN HEAT EXCHANGER AND FAN

PM45-237A

oxygen outlet duct. The trap consists of a 40 micron mesh screen filter which incorporates an integral bypass to insure operation in the event the trap would become choked with collected solids.

3-23. CABIN HEAT EXCHANGER

The cabin heat exchanger (Figure 3-15), cools the cabin gas in the same manner as the suit circuit heat exchanger except the cabin heat exchanger employs an electric driven motor fan to draw in and recirculate cabin gas. Internal structure is the same as the suit circuit heat exchanger.

3-24. CAPSULE WATER TANK

The capsule water tank is a pressurized compartmented cylindrical shaped container (Figure 3-15). Water is displaced from the tank by means of a rubber bladder which is activated by oxygen from the Coolant Quantity Oxygen bottle. Water from the tank is directed to two manual control valves which control the water supply to the suit circuit and cabin heat exchangers. The capsule water tank also provides the Astronaut with a source of drinking water.

3-25. CABIN PRESSURE CONTROL VALVE

The cabin pressure control valve, Figure 3-17, is provided to maintain cabin pressure to $5.1 \pm .3$ psia. The control valve contains two aneroids that sense cabin pressure. Whenever cabin pressure drops below $5.1 \pm .3$ psia, the aneroids partially expand and unseat the spring loaded metering pins, which in turn permit oxygen to flow into the suit circuit. The suit pressure regulator senses the increase in pressure, and relieves suit circuit pressure to the cabin. Directing oxygen flow through the suit circuit provides constant purging of suit circuit. When cabin pressure increases to $5.1 \pm .3$ psia the aneroids contract, allowing the metering pins to seat and shut off the oxygen flow. In the event of cabin decompression, or whenever cabin pressure drops below $4.0 {}^{+.2}_{-.1}$ psia,

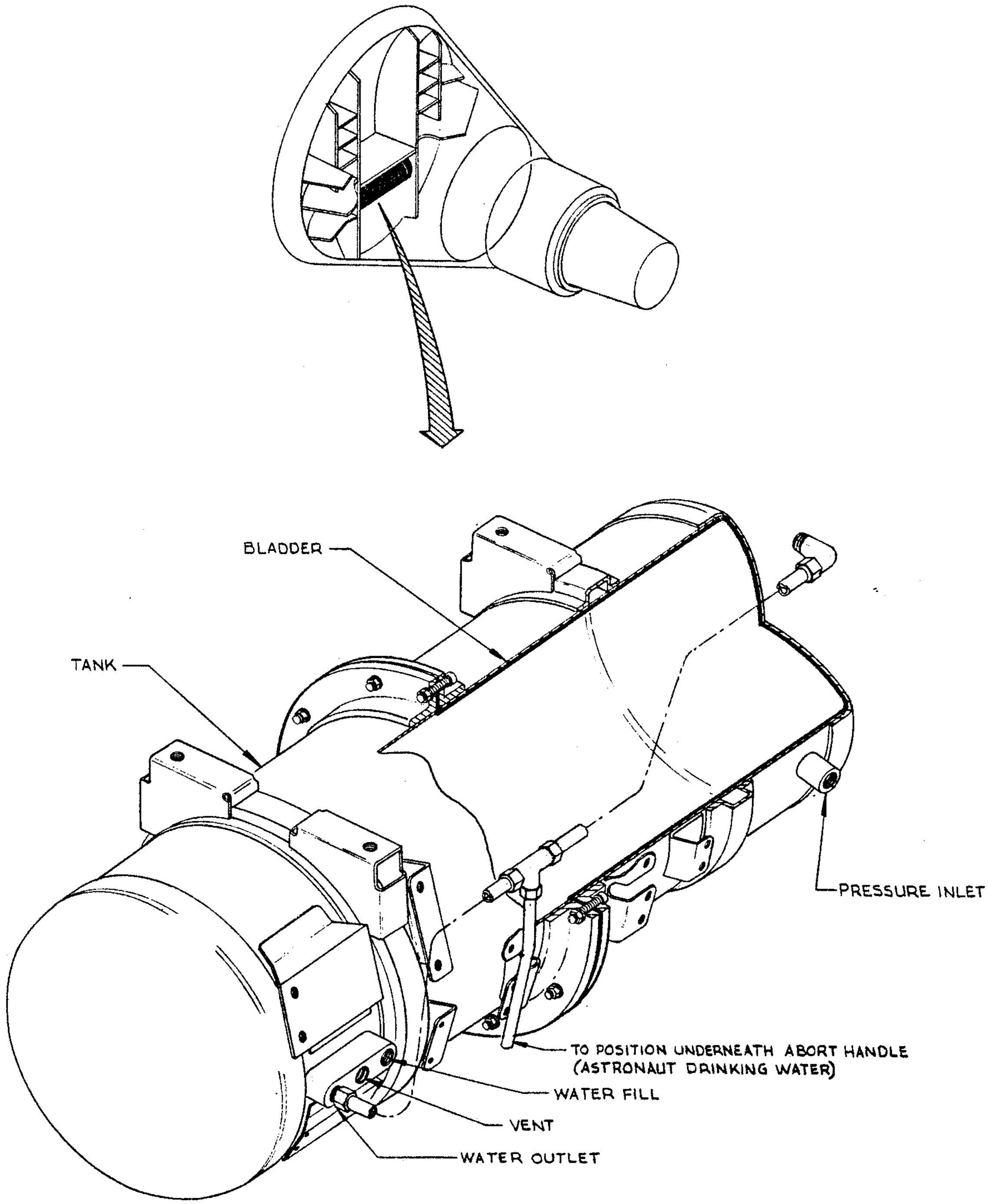


FIGURE 3-16 CAPSULE WATER TANK

PM45-238

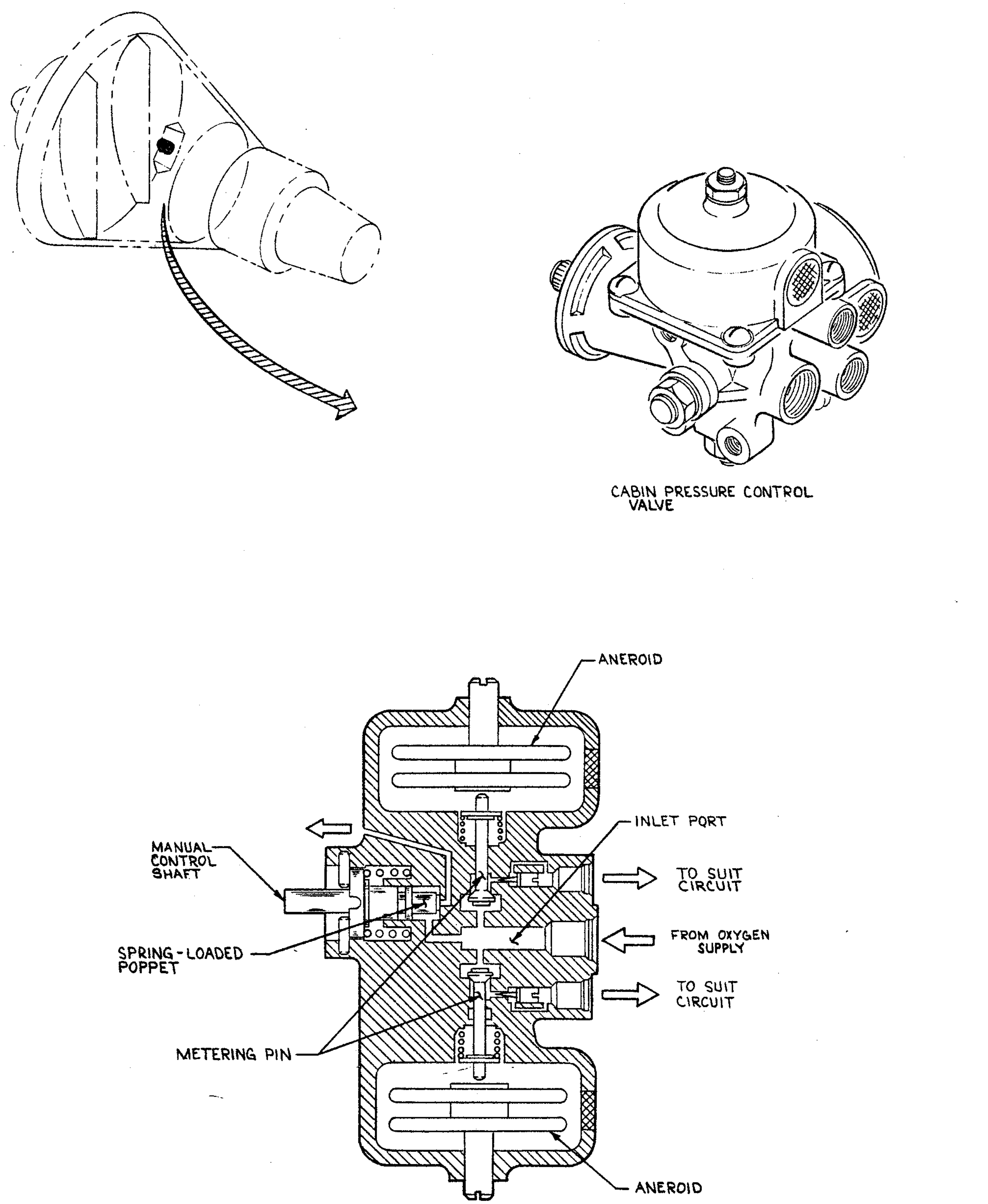


FIGURE 3-17 CABIN PRESSURE CONTROL VALVE

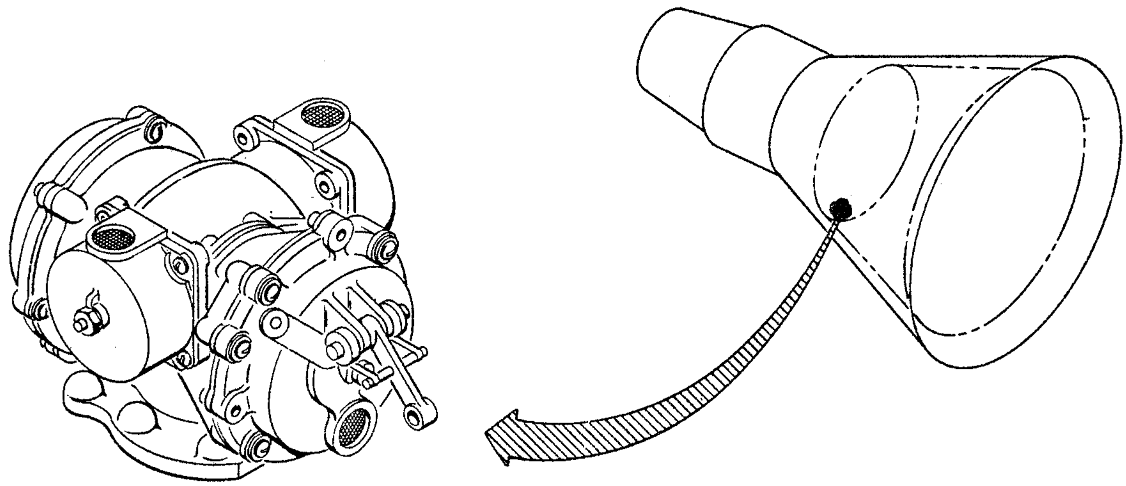
PM45-158A

the aneroids fully expand and seat against the inlet port. This prevents oxygen flow, through the cabin pressure control valve, and reserves the remaining oxygen supply for the suit circuit. Two aneroids are provided in the valve to insure operation in the event that one aneroid fails. A manual control is also provided to enable cabin repressurization in the event cabin depressurization was manually selected. Actuation of the REPRESS "T" handle, in the cabin, offseats a spring loaded poppet in the valve and allows oxygen to flow directly into the cabin. REPRESS "T" handle should then be pushed in, following cabin repressurization, to enable cabin pressure control valve automatic operation.

3-26. CABIN PRESSURE RELIEF VALVE

The cabin pressure relief valve, Figure 3-18, automatically controls cabin pressure relative to ambient pressure during launch, orbit, re-entry and landing phases. In the event of a water landing, the valve incorporates provisions to keep water from entering the cabin. The valve also features means for manually decompressing the cabin. The cabin pressure relief valve consists of a calibrated spring control section and a poppet valve control section. The calibrated spring control section incorporates ambient and cabin sensing chambers separated by a sensing diaphragm, spring loaded metering valves and calibrated springs. The poppet valve control chamber incorporates a manual control arm, a check valve, poppet stem orifices, spring loaded poppet valves, poppet chamber diaphragms and poppet chambers.

After the cabin purging operation, cabin pressure will be the same as the existing ambient pressure. During launch, as ambient pressure begins to decrease, the cabin pressure relief valve will relieve cabin pressure until the pressure differential (cabin/ambient) reaches 5.5 psia. The cabin pressure relief valve will then prevent cabin pressure build up in excess of 5.5 psia



CABIN PRESSURE RELIEF VALVE

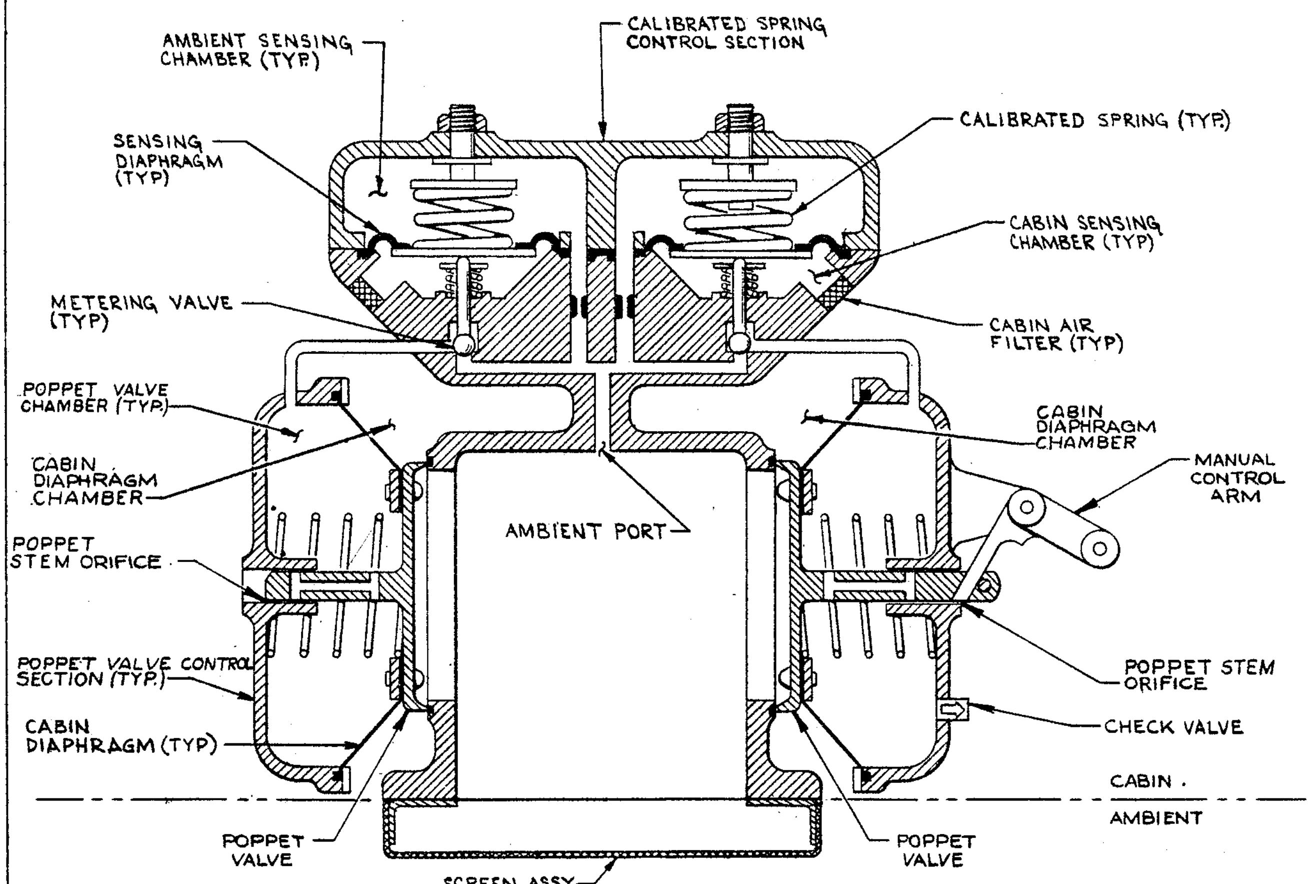


FIGURE 3-18 CABIN PRESSURE RELIEF VALVE

PM45-151-8

throughout the orbit, re-entry and landing phases. Cabin pressure will be vented, through the poppet stem orifices, into the poppet valve chamber. Cabin pressure will also be vented, through the cabin air filters, into the cabin sensing chamber. Ambient pressure will be vented, via the ambient port, into the ambient sensing chamber. The calibrated springs are designed to respond to differential pressures in excess of approximately 5.5 psi (cabin/ambient). When the pressure differential between the cabin sensing chamber and ambient sensing chamber exceeds approximately 5.5 psia (cabin/ambient), the calibrated springs will retract. The metering valves will then be lifted from their seats, allowing differential pressures in excess of 5.5 psia to escape through the ambient port. Due to the ambient port being larger than the poppet stem orifices, the dissipation rate of the excessive differential cabin pressure (inside the poppet valve chambers) will exceed the rate of buildup in the poppet valve chambers. This will momentarily cause the cabin pressure to be greater than the poppet valve chamber pressure. The greater cabin pressure will act against the cabin diaphragm, unseating the poppet valves. The poppet valves will then aid in the relieving of excessive differential pressure. If the Astronaut executes a manual decompression of the cabin, the check valve acts as an exhaust for poppet valve chamber pressure.

During orbit, the cabin pressure relief valve will prevent cabin pressure buildup in excess of approximately 5.5 psia. Cabin pressure in excess of approximately 5.5 psia will be exhausted to the outside atmosphere. Upon re-entry, when the ambient pressure becomes 15 inches of water greater than cabin pressure, the poppet valves will commence to open allowing ambient pressure to enter the cabin. Valve relieving operations will then be similar to those during launch. In the event the capsule makes a water landing, the poppet valves will not open until water pressure exceeds cabin pressure by 15 inches of water.

A manual control located on the left hand console and marked "PRESS REG" manually closes the poppet valves to prevent water from entering the cabin through the valve.

3-27. SNORKEL AND DIAPHRAGM FLAPPER VALVES

The cabin inlet air snorkel valve and the cabin outflow diaphragm flapper valve act as water check type valves. During the landing and post landing phases, (often reaching a pressure altitude of approximately 17,000 ft.) ambient air is circulated through the valves. In the event the valve parts were under water, the valves would seat and prevent water from entering the cabin.

3-28. CABIN AIR INLET VALVE

The cabin air inlet valve, Figure 3-19, provides ventilation and cooling for the suit circuit and cabin during capsule landing and post landing phases. It is a spring loaded close, spoon type valve and is barometrically controlled. Prior to capsule launch, the valve is manually latched closed so that one mechanism spring loaded detent pin rides on the large diameter of the aneroid plunger (maximum allowable pull to set detent pin is five (5) pounds); and the valve arm is engaged by the release link, which is engaged by the spring loaded aneroid locking pin. During capsule launch the aneroid expands due to decreasing cabin pressure, and forces the aneroid plunger down. The valve mechanism detent pin then slips off the plunger large diameter onto the plunger small diameter.

During capsule landing phase, when the capsule descends to an altitude of approximately 17,000 $\pm$ 3,000 feet, the aneroid retracts as cabin pressure increases. Retraction of the aneroid moves the aneroid plunger upward, engaging the detent pin against the plunger larger diameter, which in turn compresses the aneroid locking pin spring. This action raises the locking pin from release link and allows spring loaded valve to open. The valve arm is attached to valve

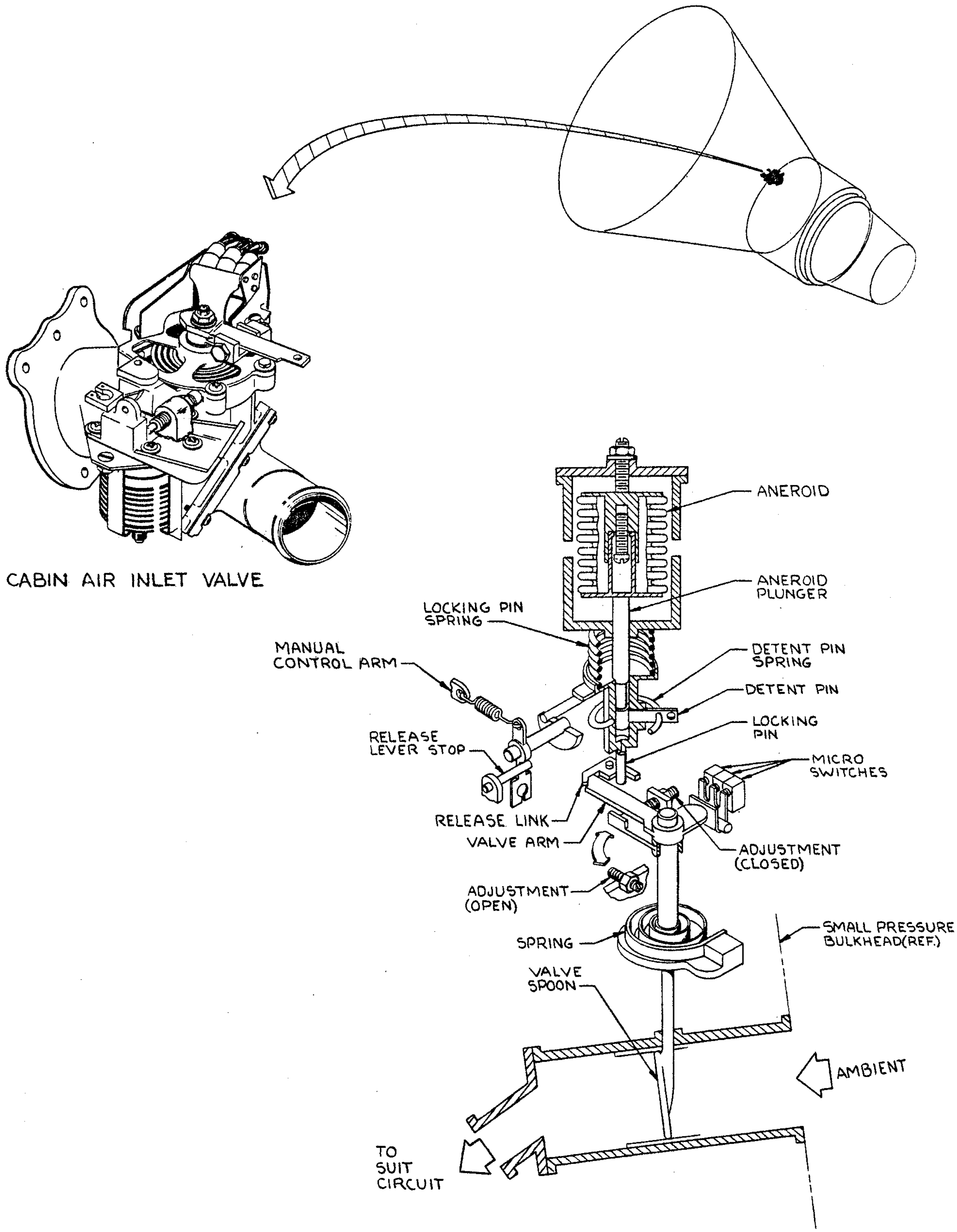


FIGURE 3-19 CABIN AIR INLET VALVE

PM45-154B

shaft and moves with closing, thereby disengaging micro-switches. Disengagement of micro-switches directs electrical power to stop cabin fan operation and close the suit circuit shutoff valve, which in turn opens the emergency oxygen rate valve. A manual control arm is provided to enable valve opening in the event valve failed to open at specified altitude. Actuation of the manual control arm, mechanically, contacts the locking pin spring and disengages locking pin from release link, allowing valve to open. In the event of a capsule low altitude abort, an explosive squib will force the locking pin up, to enable valve opening. Valve must be manually reset to close position. Opening of the valve enables suit compressor to draw ambient air into suit circuit to provide suit circuit and cabin ventilation.

The cabin air outlet valve is basically of the same construction and functions in the same manner as the cabin air inlet valve.

3-29. VACUUM RELIEF VALVE

The vacuum relief valve, Figure 3-20, is designed to open at a pressure differential of 10 to 15 inches of water, to provide suit circuit ventilation whenever the inlet snorkel valve closes (ball float seats). The relief valve is located in the flexible ducting, between the cabin air inlet valve and the suit circuit inlet duct. In the event the capsule submerges momentarily, following a water landing, the snorkel valves ball floats will seat (close) and prevent water from entering into the suit circuit and cabin. The operation of the suit circuit compressor and the closed air inlet snorkel valve will create a vacuum in the suit circuit air inlet duct (flexible ducting). When cabin pressure exceeds the flex duct pressure, by 10 - 15 inches of water, the vacuum relief valve will open. As the valve opens, cabin pressure acting on the valve poppet surface will be great enough to hold the valve open until the pressure differential (between cabin and duct) is approximately 2 inches of water or less. Suit

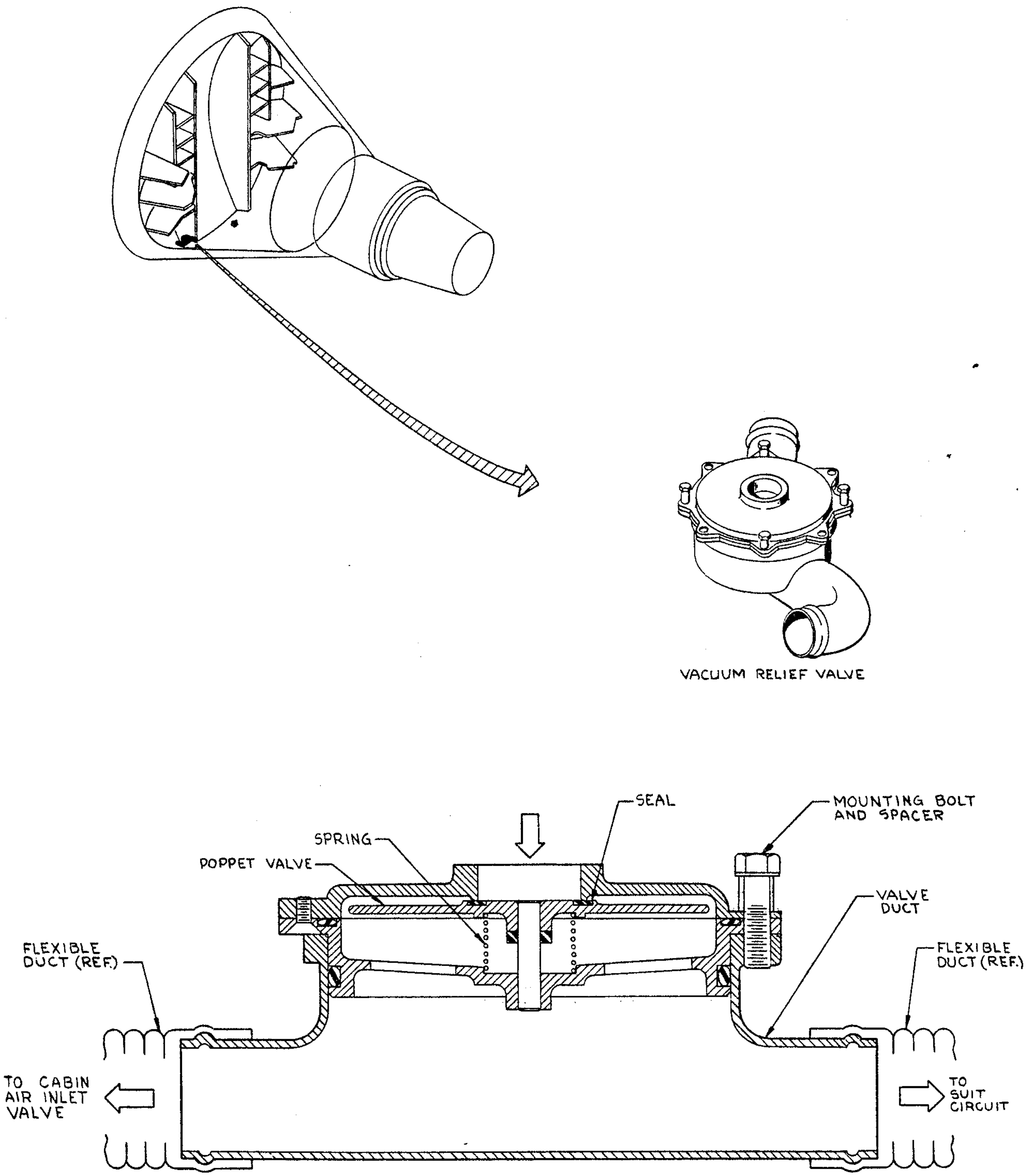


FIGURE 3-20 VACUUM RELIEF VALVE

PM45-226B

circuit ventilation is provided by the cabin air, entering the opened vacuum relief valve, whenever the inlet snorkel valve ball float is seated (closed). Also, the opening of the relief valve removes the vacuum in the flex duct to enable the snorkel valve ball float to unseat (open) whenever the snorkel valve is above water.

3-30. TEST CONFIGURATION CAPSULES

3-31. TEST CONFIGURATION CAPSULE NO. 8

Capsule 8 environmental control system differs from the specification capsule in the following manner.

Capsule 8 environmental control system is the same as Capsule 2 and 3 except for the following: Capsule 8 will incorporate a cabin O_2 pressure warning light but this warning light will not be supplemented with a tone generator circuit. There is no indicating system to reflect O_2 emergency operation. Capsule 8 will incorporate a circulation fan to aid in cooling the special instrumentation package. The air inlet and outlet valves open at 17,000 ± 3,000 feet. The air outlet valve is the same as Capsule 2 and 3. Capsule 8 does not contain heat exchangers to cool the main and standby inverters, nor does it contain manual provisions for closing the cabin pressure relief valve poppet valves.

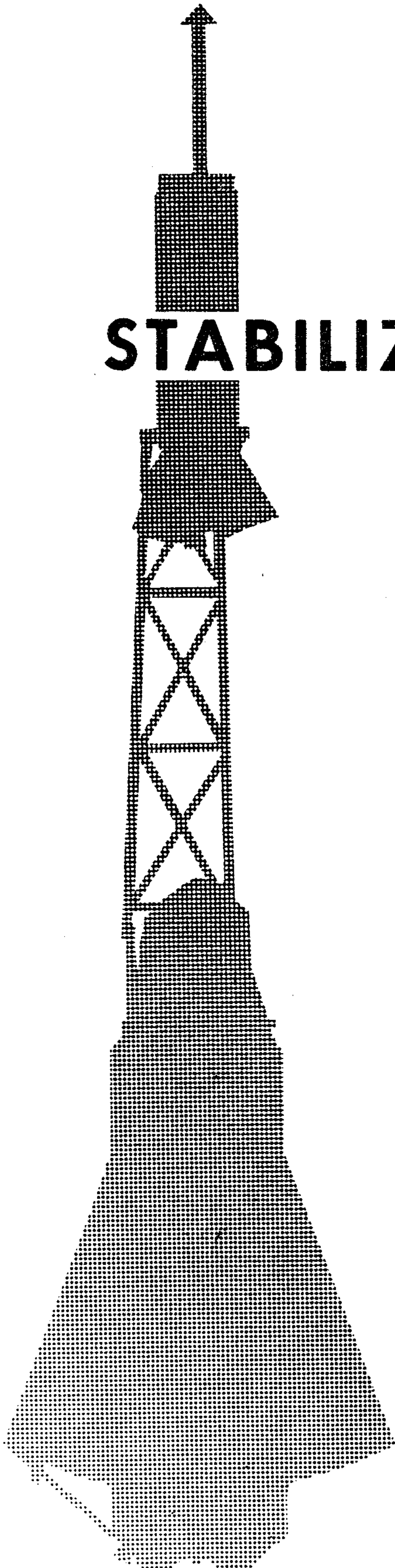
3-32. TEST CONFIGURATION CAPSULES NO. 9, 10 AND 13

Capsules 9, 10 and 13 environmental control systems are basically the same as the specification capsule except as follows: Capsule 9 solids trap is designed for a primate; it does not contain heat exchangers to cool the main and standby inverters; the water separator is deactivated; and the water tank is not utilized as a source of drinking water for the Astronaut. Capsule 9 suit circuit does not incorporate a suit O_2 partial pressure system; and the suit circuit does not incorporate a constant bleed oxygen system.

3-33. TEST CONFIGURATION CAPSULE NO. 16

Capsule 16 environmental control system is basically the same as the specification capsule.

SECTION IV



STABILIZATION CONTROL SYSTEMS

TABLE OF CONTENTS

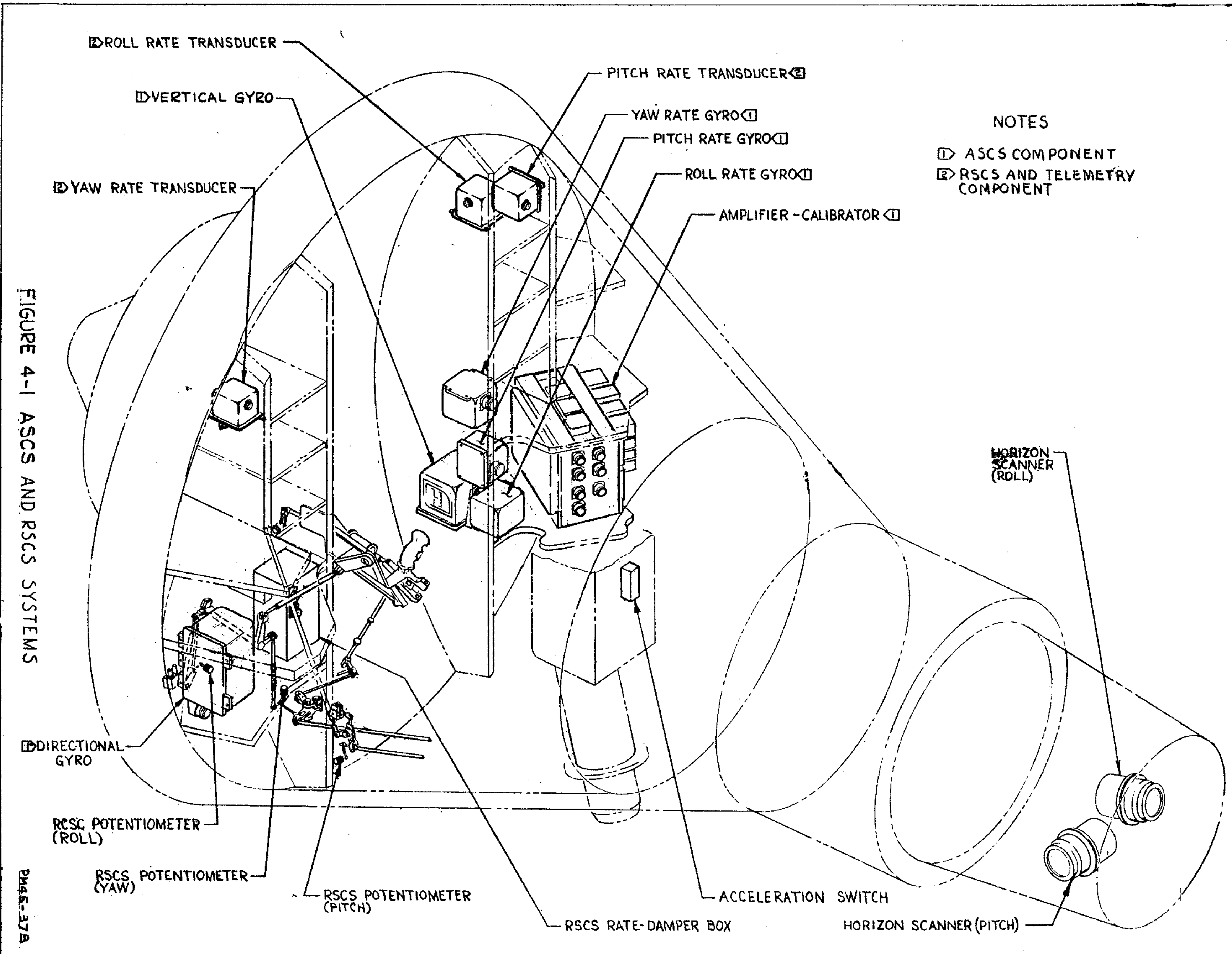


FIGURE 4-1 ASCS AND RSCS SYSTEMS

PM45-37B

IV. STABILIZATION CONTROL SYSTEMS

4-1. GENERAL

Stabilization of the capsule in space is accomplished by the Automatic Stabilization Control System in conjunction with two sub-systems, the Horizon Scanners and the Reaction Control System. These systems establish and maintain a stable platform with four basic automatic modes; Damper, Orientation, Attitude Hold and Re-entry. A redundant rate "back-up" system, the Rate Stabilization Control System (RSCS), is also provided. The RSCS provides the Astronaut with an emergency method of controlling the capsule with a "rate-stick" in the event of a failure in the Automatic Stabilization Control System. In addition, a visual indication of yaw, roll, and pitch attitude is provided. The following paragraphs 4-2 through 4-56 briefly describe the individual systems and functions involved for the specification compliance capsule.

4-2. AUTOMATIC STABILIZATION CONTROL SYSTEM

4-3. SYSTEM DESCRIPTION

The Automatic Stabilization Control System (ASCS) is composed of a Directional Gyro, Vertical Gyro, .05g accelerometer switch, Rate Gyros (yaw, roll and pitch), a rate damper, and an Amplifier Calibrator Unit. Location of the individual components within the capsule is shown in Figure 4-1. Total weight of the ASCS is approximately 59 pounds.

Three switches are provided in conjunction with the ASCS. The GYRO switch AUTO/RATE COMD switch, and the NORM-AUX DAMP-FBW switch are located on the Astronaut's left console. With the NORM-AUX DAMP-FBW switch in the NORMAL position and the AUTO-RATE COMD switch in AUTO, stabilization is accomplished in a completely automatic manner, requiring no assistance from the Astronaut. In the FLY-BY-WIRE position, the automatic feature is disabled and 24 V d-c power is connected to the Fly-By-Wire limit switches on the Astronaut's control stick. In this position stabilization is accomplished through an electro-mechanical arrangement (See Figure 4-9) by movement of the Astronaut's control stick in the desired plane. Low and high thrust actuation occur at approximately 30% and 75% of full travel, i.e., 3.9° and 9.8° for yaw, pitch, or roll. The AUX DAMP position disables both the automatic and fly-by-wire function, permitting rate damping as a singular feature. The GYRO switch is a three position switch incorporating a CAGE, FREE, and NORMAL position. In the CAGE position the Attitude gyros are mechanically caged and the Horizon Scanner slaving function is disabled. In the FREE position theAttitude gyros are uncaged; the Horizon Scanner slaving function remains disabled. The NORMAL position uncages the attitude gyros and permits Horizon Scanner slaving. The AUTO/RATE COMD switch provides a method of energizing either the RSCS or ASCS systems as desired. In the RATE COMD position, the attitude gyros and slaving circuits remain energized although they are not used to control the capsule. (See Figure 4-12.)

4-4. ASCS Sequencing

The following paragraphs, 4-5 and 4-9, describe the ASCS sequential operation under normal and abort conditions. Figures 4-2, 4-3 and 4-4 are provided for clarity and should be followed closely in conjunction with the text concerning the various modes of operation.

4-5. Normal Sequencing

In Figure 4-2, the progress of a normal orbital mission is shown divided into eight phases appropriate to the following discussion.

The ASCS is in the "ready" status prior to separation of the escape tower, its gyros are running and all circuits except the final 12 output relays are fully energized. RSCS operation is prevented by the AUTO/RATE COMD switch being in the AUTO position. Phase (A), involving gyro slaving to the Horizon Scanner

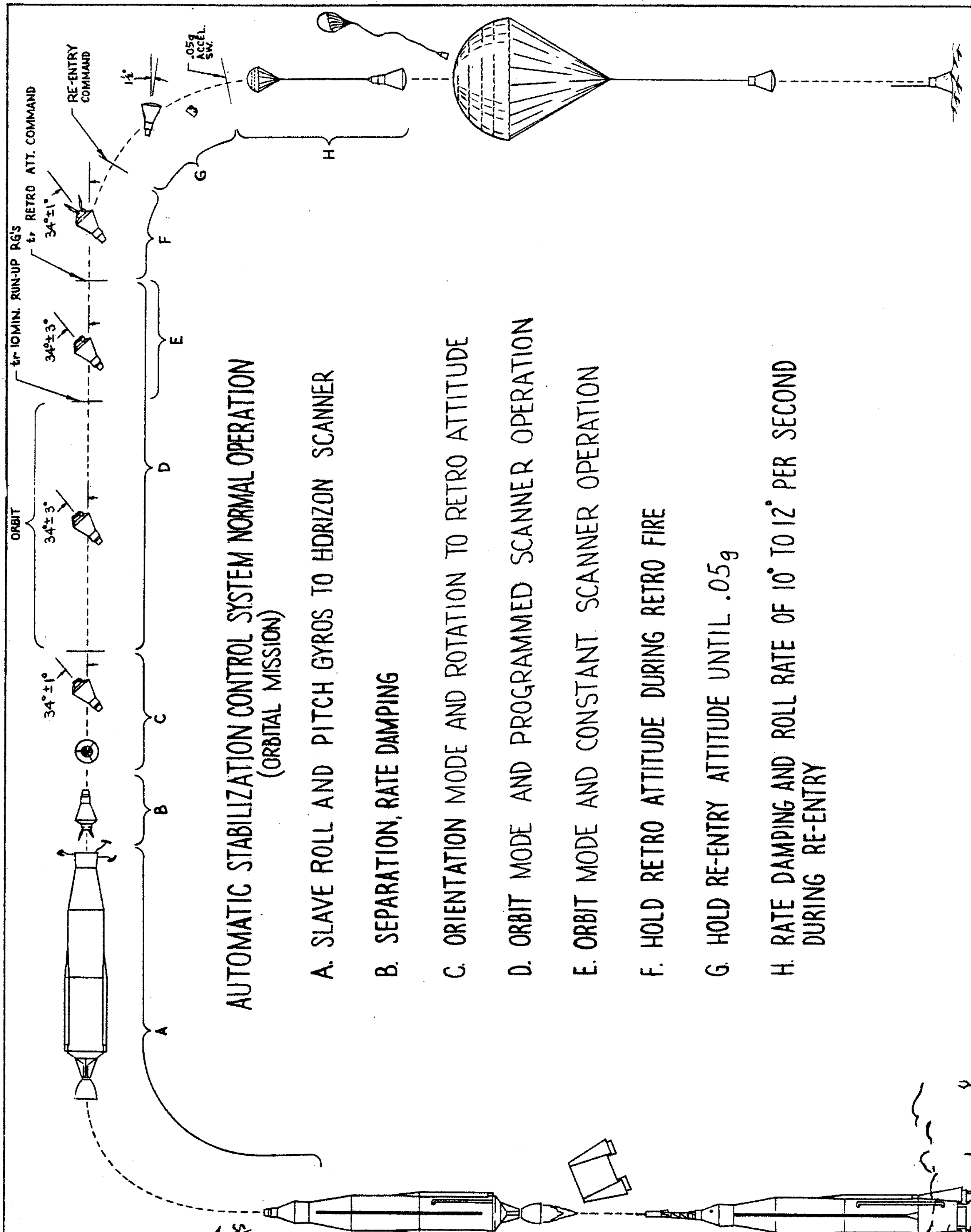


FIGURE 4-2 ASCS NORMAL OPERATION

pitch and roll outputs during ascent, is to minimize gyro errors which may accumulate while the capsule is being boosted.

Phase (B) starts after capsule separation when a brief, five-second signal commands the ASCS to provide rate damping to stop any tendency to tumble.

Phase (C) is initiated at the completion of five seconds of rate damping. The ASCS is placed in the orientation mode, capsule turn around (180° counter-clockwise Yaw Rotation) is accomplished, and the capsule is pitched-down to the retrograde firing angle within 30 seconds. Pitch, roll and yaw gyro slaving to the Horizon Scanners is provided during phase (C) and for the first 4½ minutes of phase (D) to yield a good yaw-angle reference prior to settling down in orbit.

In phase (D) the capsule is in orbit. An orbit pitch attitude of -34° (small end down) is held so that the capsule is ready for an immediate abort. The attitude gyros are slaved to the Horizon Scanner at a cycle of 8.5 minutes on, 21.5 minutes off, throughout phase (D). During the orbit phase manual control and fly-by-wire control may be utilized as desired. Rate damping becomes optional under manual control conditions by positioning of the ASCS MODE SELECT switches and RCS controls. By switch manipulation, rate damping is provided by either the ASCS or RSCS. See Paragraph 4-3. Rate gyro run-up is continued throughout phase (D). Another feature utilized in Phase (D) is an automatic return to the orientation mode. If the capsule drifts (from orbit attitude) beyond the limits of the retro-interlock sector switches, automatic return to orientation mode will occur at ± 12° pitch, ± 30° yaw and roll. The Astronaut can also place the ASCS back in the orientation mode by manipulation of the AUTO/RATE COMD switch.

In phase (E) of Figure 4-2, rate gyro run-up is automatically assured by relay switching 10 minutes prior to retrograde attitude. Horizon Scanner slaving operation becomes constant at this time to obtain a good reference prior to

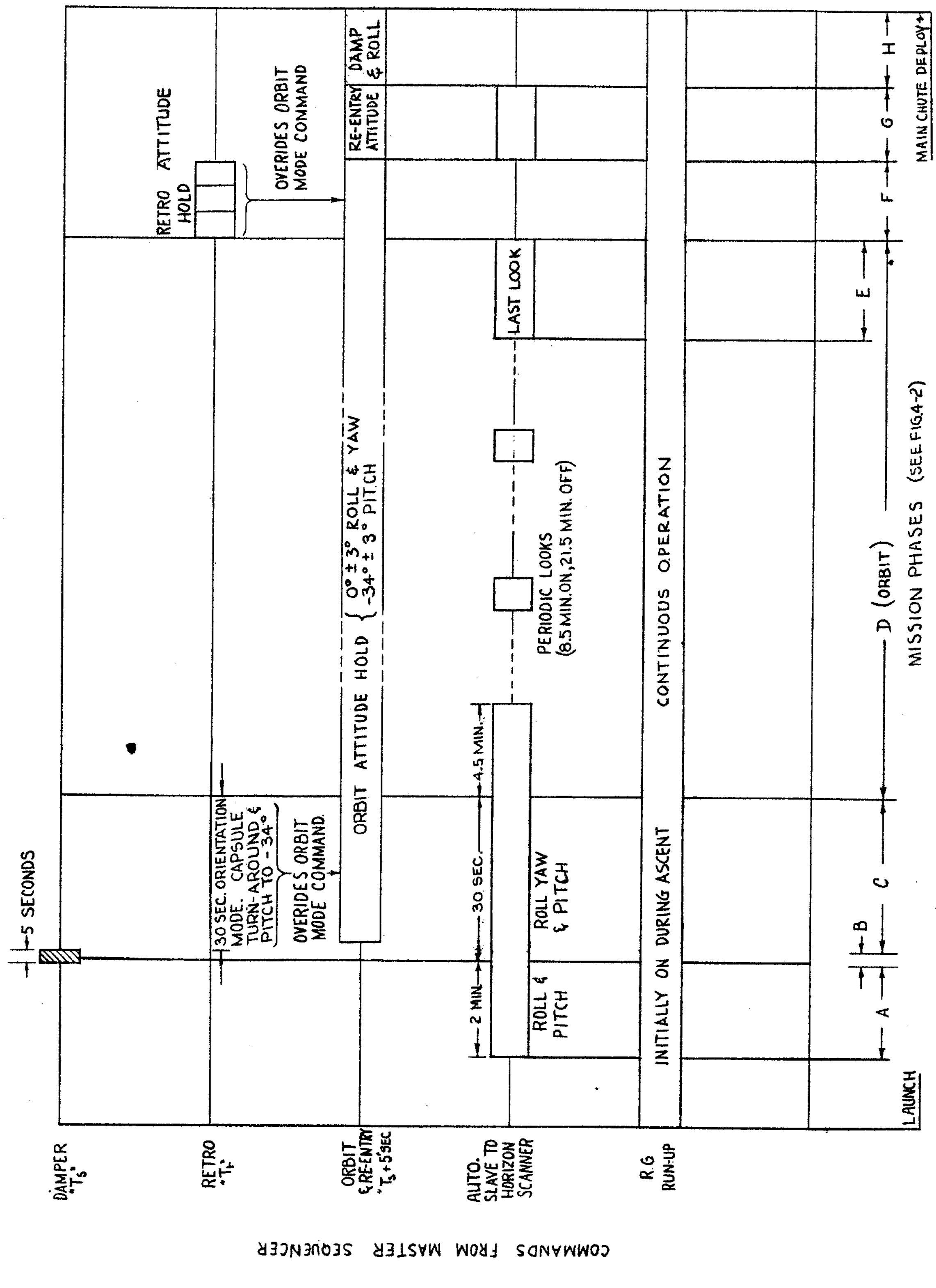


FIGURE 4-3 ASCS MISSION PROFILE

PM45-55

achieving retro-attitude. The Astronaut may change any one or all three of the capsule attitudes maintained by the ASCS by changing the space reference plane or planes of the attitude gyros. To maintain the new reference plane or planes, the Horizon Scanner slaving command must be stopped by placing the gyro switch in the Free position. New reference planes may be established by the Astronaut while the ASCS is in operation by placing the gyro switch in the Free position, manually turning off the ASCS fuel in the axis or axes affected, utilizing manual control to position the capsule, and then caging and uncaging the gyros. The ASCS may then be returned to fully automatic operation in all three axes with the exception of Horizon Scanner slaving. To utilize Horizon Scanner slaving, the capsule attitudes must be within the observation range of the scanners and the gyro switch must be placed in the Normal position.

The ASCS receives Tr signal and maintains capsule in high torque retrograde attitude (phase F). Horizon Scanner slaving is discontinued at this time. Thirty seconds after retrograde attitude command, the retro rockets are fired. During the period of retrograde rocket firing the ASCS utilizes high torque action to hold the capsule within one degree of the ideal angles. Retrograde rocket firing command and ASCS high torque switching command occur simultaneously. Rocket firing is completed in 20 seconds and the high torque switching command is held for 23 seconds.

Upon completion of retro package jettison, the ASCS automatically pitches the capsule to the post-retro fire attitude (phase G) in preparation for re-entry drag. The ASCS returns to orientation mode with constant scanner operation to accurately maintain the re-entry attitude.

Finally, when re-entry is sensed by the .05g accelerometer switch, the eighth and last phase (H) of the ASCS performance starts with the turning off of the attitude gyro power. During this period the ASCS initiates and maintains a constant roll rate of 10° to 12° per second to minimize touchdown dispersion. Rate damping is provided to stabilize the re-entry trajectory. ASCS operation in this phase continues until main chute deployment, at which time all ASCS power is removed.

Pilot-override provisions permit interruptions of the preceding "normal" sequence by manual, fly-by-wire or RSCS stick-steering control manipulation and return to the "normal" ASCS MODE. Thus to a significant degree the Astronaut is the intelligent "back-up" for the ASCS. Full utilization of this reliability augmentation principle has led to gyro caging and other switching features which are intended to make the capsule manually controllable. The following table lists the switch and control positions necessary to achieve the four basic modes of control after attaining orbit. Variations of the various modes can be obtained by further switch manipulation. A more detailed discussion of the control modes available is contained in SEDR 109, Capsule Flight Operations Manual.

CONTROL MODE	SWITCH POSITION Auto/Rate Comd	SWITCH POSITION Norm-Aux Damp-FBW	RCS "T" HANDLE POSITION Auto Fuel Sys.	RCS "T" HANDLE POSITION Manual Fuel Sys.
AUTOMATIC	AUTO	NORMAL	PUSH ON	RATE COMD
FLY BY WIRE	AUTO	FLY BY WIRE	PUSH ON	RATE COMD
RATE-STICK	RATE COMD	NORMAL	PULL OFF	RATE COMD
DIRECT (With Rate Damper)	AUTO	AUX. DAMP	PUSH ON	DIRECT

4-6. Abort Sequencing

In general, abort sequencing (See Figure 4-4) is programmed to correspond to the safest procedures at all times. The possible abort situations can be divided into three types, namely (1) abort, before tower separation when ASCS rate damping is required; (2) abort after tower separation but before the trajectory is truly orbital; and (3) abort from orbit. The following paragraphs,

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

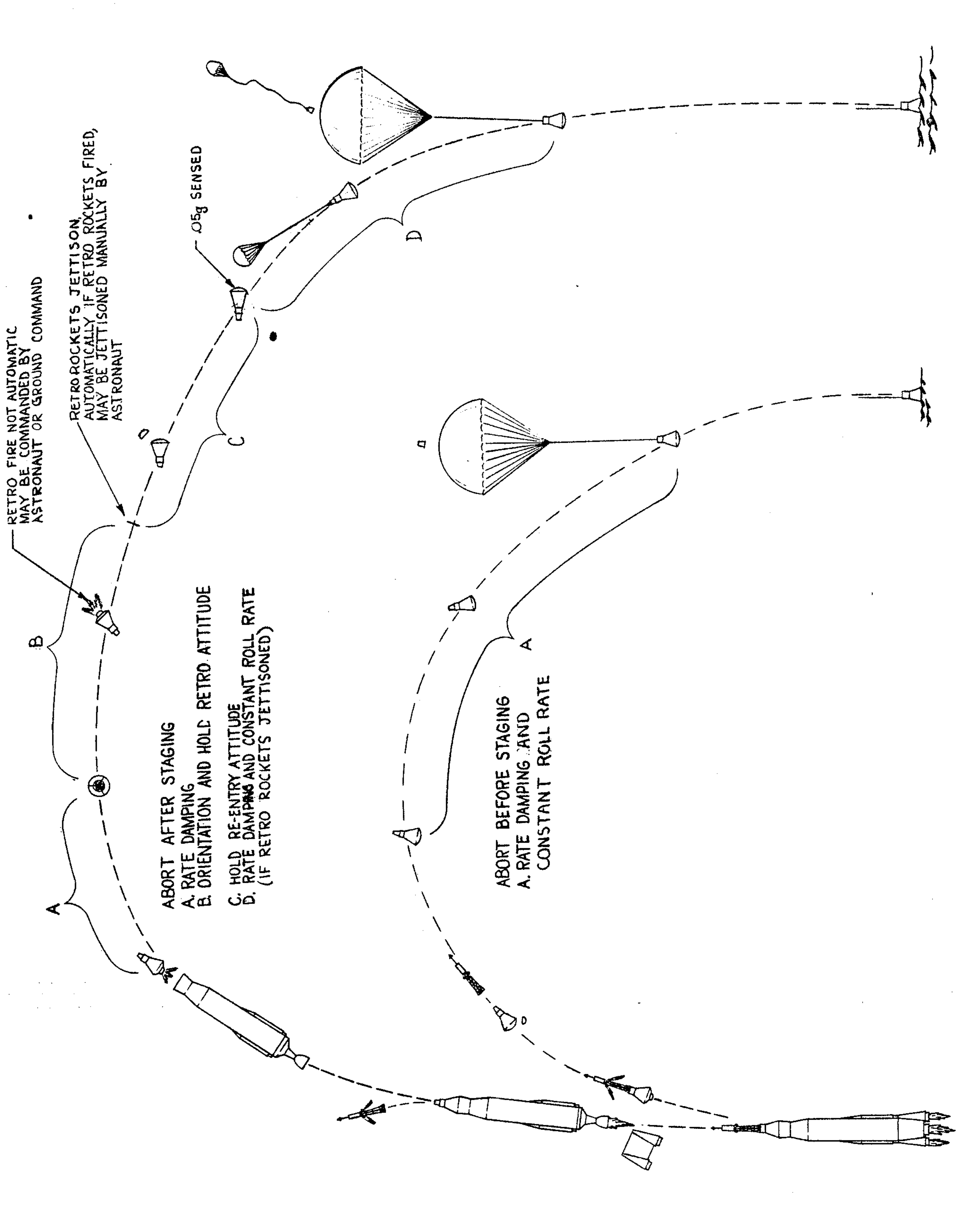


FIGURE 4-4 ASCS EMERGENCY OPERATION

DM45-39C

4-7 through 4-9, discuss ASCS sequencing in each of the abort conditions.

4-7. Abort Before Tower Separation

If an abort mission is started during the period when the booster and sustainer engines are burning, the ASCS is utilized for rate damping only after the following external operations have been achieved.

(1) Booster and sustainer engines cut-off.

(2) Capsule separation from adapter.

(3) Escape tower rocket firing.

(4) Retro rocket separation from capsule.

(5) Timed arrival at approximate peak of trajectory.

(6) Separation of escape tower from capsule.

Upon completion of the latter operation, the ASCS is commanded to provide rate damping, using the rate gyros which are continuously energized during the normal ascent and "abort trajectory" flight. A constant roll rate of 10° to 12° per second is employed. Rate damping ceases upon deployment of the main chute.

4-8. Abort After Tower Separation

The first operation is engine cut-off. This is followed immediately by capsule separation, posigrade firing, and the normal mission post-separation signal sequence to the ASCS. The effect is immediate damping of any capsule tendency to tumble. After 5 seconds of rate damping, the automatic sequence commands capsule turn around an an attitude angle of 34 degrees. Then either the Astronaut or Ground Command must initiate retrograde sequencing. Upon achieving the proper roll, pitch and yaw angles within rather wide "permission" bounds (See Paragraph 4-5, Page 4-6), the ASCS enables rapid-sequence retro rocket firing to proceed.

NOTE

ASCS "permission interlock" during retro fire can be overridden at any time by the Astronaut. It is also noted that the Astronaut may switch to the Rate Stabilization Control System at any time should a malfunction occur in the Automatic Stabilization Control System.

After retrograde operation, the abort mission in this case proceeds as in the normal mission post-retrograde sequence (except for the difference in trajectory time and distance intervals).

4-9. Abort From Orbit

Whenever an abort from orbit is initiated, the normal automatic or manual retrograde operations will apply. However, if manual retrograde operations are utilized the pre-retrograde period of gyro slaving to the Horizon Scanners ("last look") will be eliminated.

4-10. SYSTEM OPERATION

Overall system operation is best explained by Figure 4-5. The Amplifier Calibrator receives inputs from sensors on the left side of the page and generates outputs to Display and Reaction Control devices on the right. The four basic operations are slaving, repeating, mode switching and torque switching. Data flow pertaining to the individual Yaw, Roll and Pitch channels is illustrated in Figures 4-6, 4-7 and 4-8. In general, these diagrams are straightforward and require no explanation. However, the method utilized in deriving Directional information is unique to a degree and warrants the following discussion.

The Pitch gimbal (vertical gyro) is processed continuously during the orbital phase of the normal mission, so that the capsule "local vertical" reference revolves 360 degrees during each orbital cycle. The gyro slaving principles which permit Directional (yaw) information to be derived are as follows: After initial slaving and settling of the roll and pitch loops, the

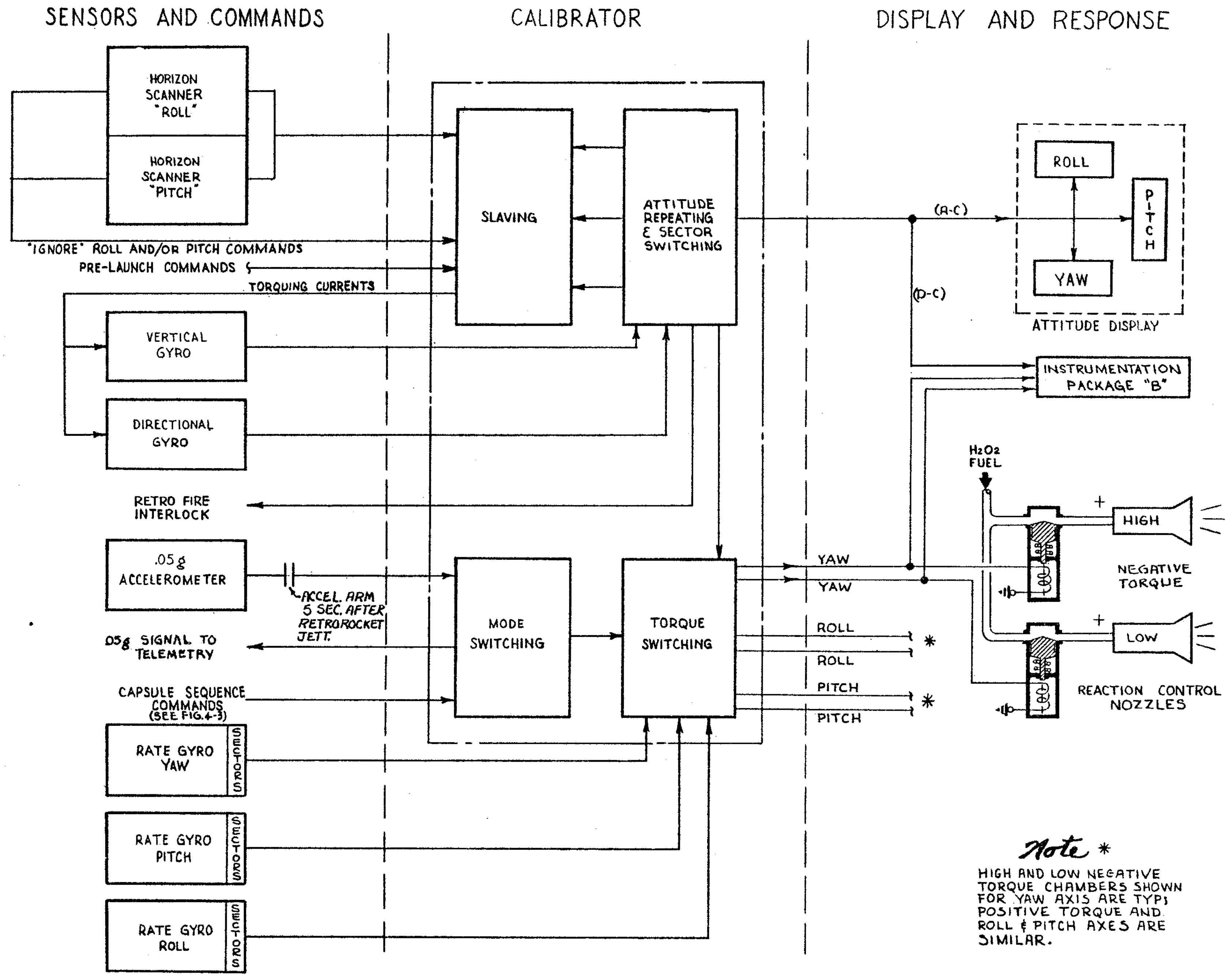


FIGURE 4-5 ASCS BLOCK DIAGRAM

CONFIDENTIAL

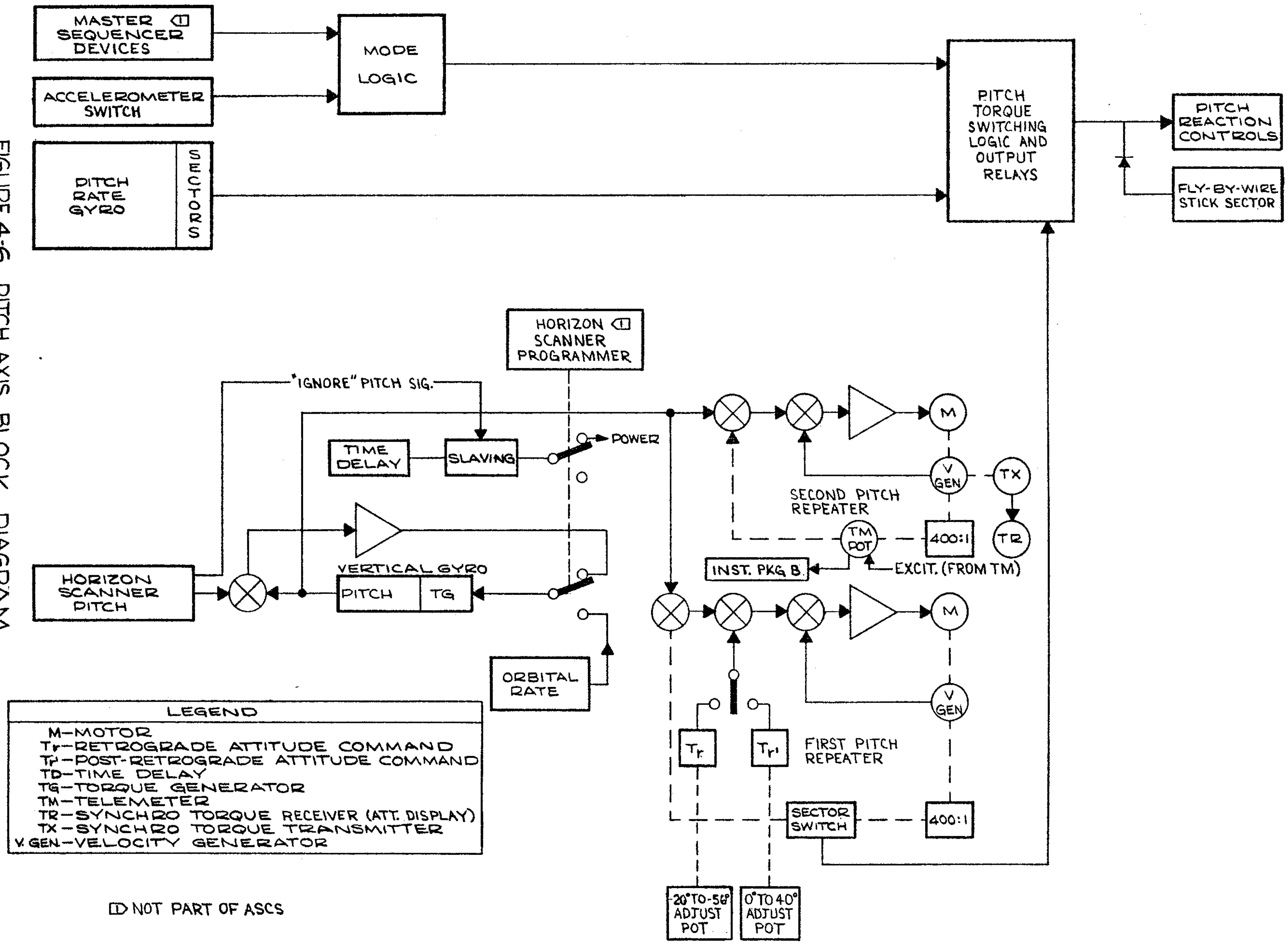


FIGURE 4-6 PITCH AXIS BLOCK DIAGRAM

PM45-42C

CONFIDENTIAL

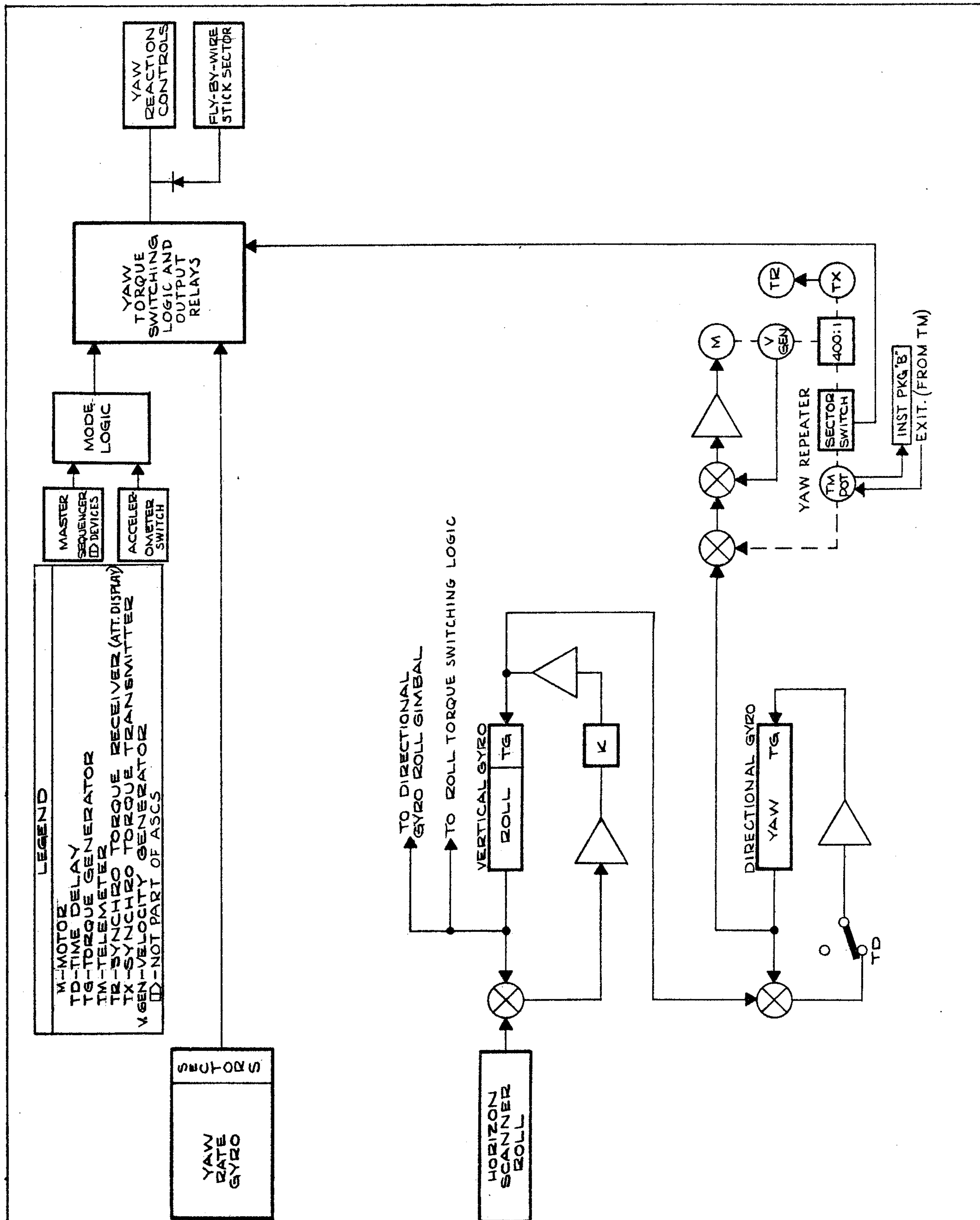


FIGURE 4-7 YAW AXIS BLOCK DIAGRAM

PM45-438

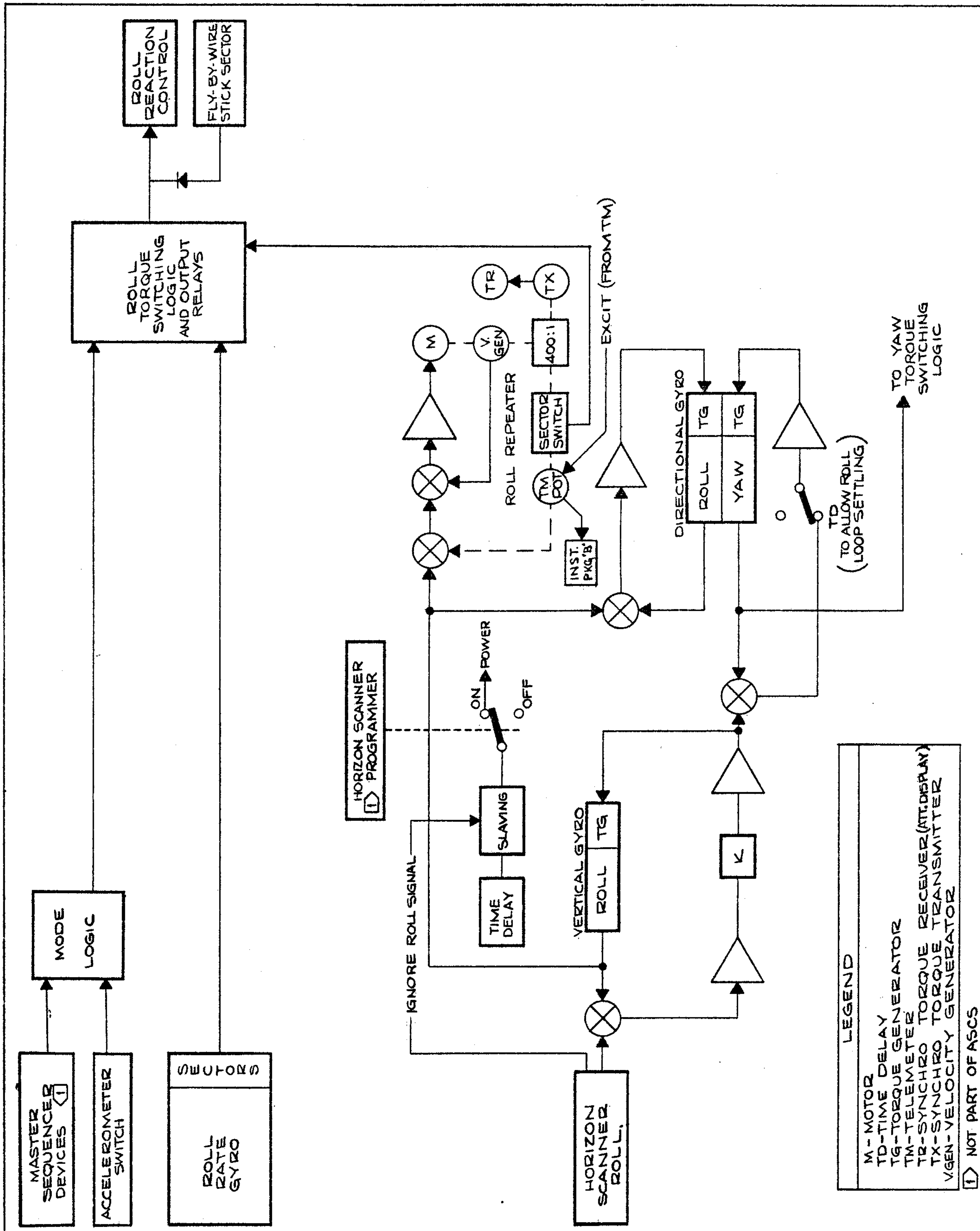


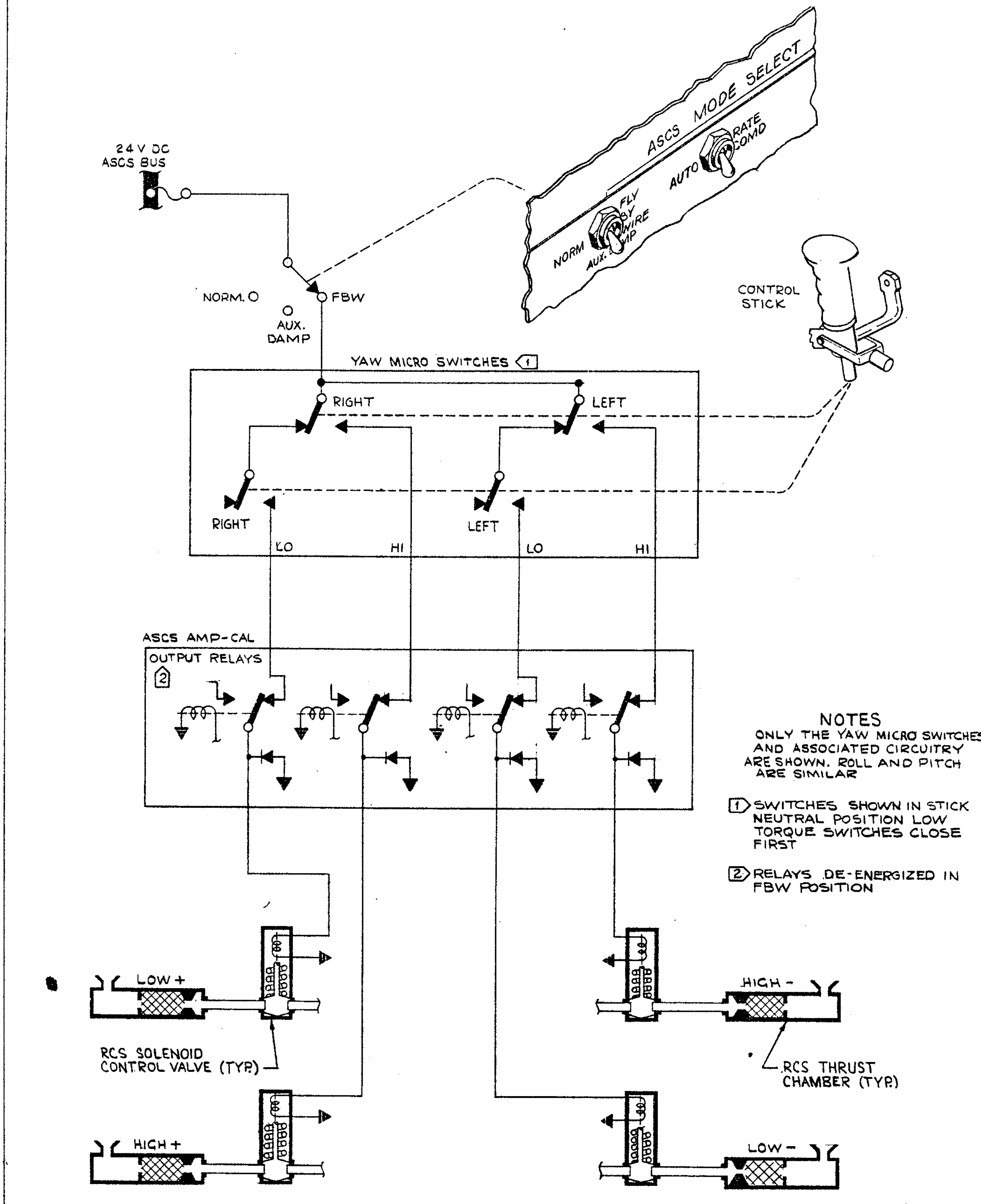
FIGURE 4-8 ROLL AXIS BLOCK DIAGRAM

PM45-44B

ASCS controls the capsule to the command pitch attitude, and to level roll attitude. Initially, after separation and capsule turn-around, some yaw error (as great as 10 degrees) may exist due to directional drift during boost. Since the Roll gimbal of the vertical gyro is the inner gimbal, yaw misalignment of the capsule causes the Roll gimbal output to contain an error component due to the constant orbital (pitch) angular rate. Thus a comparison of the Roll Horizon Scanner and vertical gyro roll indications will provide an error signal producing a roll gimbal torquing rate. This torquing rate which is a direct function of yaw error is used to slave the yaw gimbal of the directional gyro.

Another area that warrants discussion is that of torque switching, i.e., the thrust output of the Reaction Control System in conjunction with the various modes of ASCS operation.

Figure 4-10 serves as an introduction to the torque switching behavior of the ASCS. For maximum conservation of control fuel, the behavior varies according to the ASCS mode appropriate at a given time. A so-called "phase-plane" plot of angular rate vs. angle is shown in the lower right corner of Figure 4-10 adjacent to a typical Pitch time-history for the "Orbit" mode. Current ASCS design permits a plus or minus three degree oscillation about the nominal orbital attitude, which in turn is referenced to the Horizon Scanner's sensed "Horizontal". The oscillation is non-sinusoidal because of the discontinuous torque program; pitch rate is a square wave, and pitch angle a sawtooth, both having a characteristic period of 240 seconds. Portrayed on the Phase-plane, the "Orbit" mode oscillation is a gentle drift from -3 degrees relative pitch angle to +3 degrees relative pitch (-37° to -31° degrees, referenced to true horizontal). This drift lasts for approximately one-half-period of two minutes. When the error becomes +3 degrees, a low torque pulse causes the angular rate to reverse from $+\frac{1}{2}$ to $-\frac{1}{2}$ deg/sec., where upon the second half-period is spent drifting



NOTES
ONLY THE YAW MICRO SWITCHES AND ASSOCIATED CIRCUITRY ARE SHOWN. ROLL AND PITCH ARE SIMILAR

1 SWITCHES SHOWN IN STICK NEUTRAL POSITION LOW TORQUE SWITCHES CLOSE FIRST

2 RELAYS DE-ENERGIZED IN FBW POSITION

FIGURE 4-9 ASCS FLY-BY-WIRE CONTROL

PM45-408

slowly through zero to -3 degrees error.

As another example of ASCS torque-switching, Figure 4-10 shows the "Retrograde-Hold" torque logic phase-plane diagram. In this case high-torque nozzles are utilized instead of the low-torque nozzles which were adequate to control the gentle orbit oscillation. A series of attitude gyro repeater sector switches and rate-gyro pickoff sector switches are used to define step-like boundaries within the phase-plane. A typical contour is shown to illustrate the motion resulting from a large disturbance torque while in this mode. When the capsule motion results in a pitch rate value above the right-hand stair step, high negative torque is applied until the capsule attains a negative rate and rotates into the "no-torque" region. The inverse occurs if the retro-rocket thrust eccentricity or other disturbances force the capsule into a situation calling for positive thrust. The net effect of the torque-switching logic shown is to maintain rapid and reliable control during the important operation of retrograde firing.

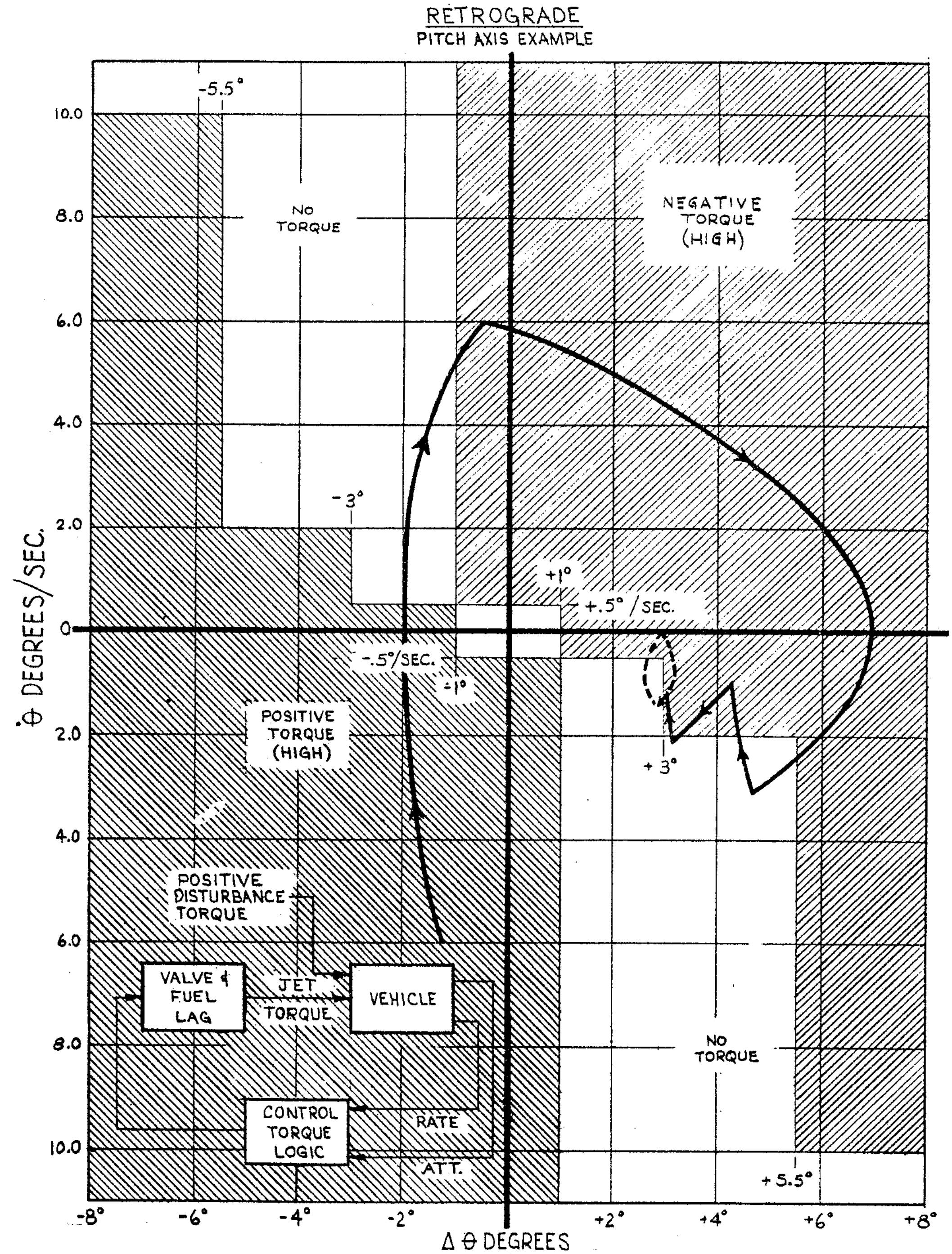
Other modes of operation requiring torque switching logic are "Orientation" and "Rate Damper". During orientation mode both high and low torquing is utilized to rotate the capsule to new preset attitudes. Both high and low torque is also applied during rate damper mode but only rate gyro signals are needed as a basis for switching logic. In this case, torque switching boundaries are horizontal lines on the phase-plane.

4-11. SYSTEM UNITS

4-12. Amplifier Calibrator

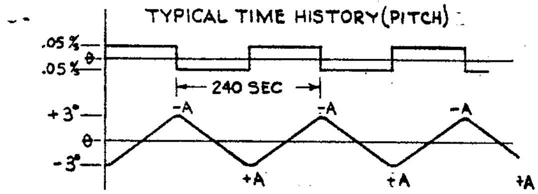
The Amplifier Calibrator unit can be "functionally" divided into four sections. These functional sections are slaving, repeating, mode switching and torque switching.

RETROGRADE
PITCH AXIS EXAMPLE



ORBIT
(PITCH AXIS EXAMPLE)

TYPICAL TIME HISTORY (PITCH)



PULSE	DURATION IN SEC.
±A	0.2
±B	0.147
±C	0.252
±D	0.437
±E	0.755

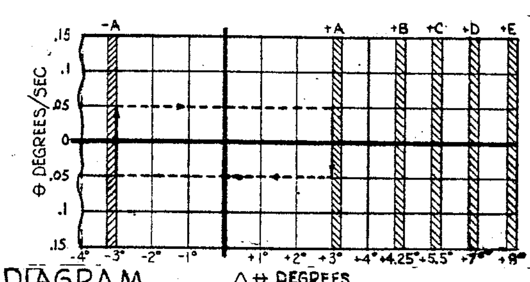


FIGURE 4-10 TORQUE LOGIC PHASE PLANE DIAGRAM

PM45-56A

4-13. Attitude Gyro Slaving

This section contains amplifiers and summing networks which accept roll and pitch information from the Horizon Scanners and generate currents to torquers in the attitude gyros. Thus, upon command from an external timing device, the Gyros' Roll, Pitch and Yaw gimbals are aligned with corresponding directions in, or perpendicular to the orbit plane. (Ref. Para. 4-10.)

4-14. Repeater Section

The repeater section is a group of servo-mechanisms (four in present design, including two for pitch angle repeating). Attitude gyro outputs, which are received at the calibrator in proportional or "analog" form, are amplified and used to drive shafts which serve as roll, pitch and yaw signal sources for both internal (torque switching) and external (display and telemetry) purposes. The on-off reaction control of the Mercury Capsule makes it desirable to use conductive sectors on the shafts of three of the repeaters. The sectors serve as attitude-level references for torque switching.

4-15. Mode Switching Section

This section of the Calibrator establishes the proper attitude angle bias, torque switching status, and interlock signals corresponding to the ASCS mode commanded by external devices.

NOTE

The sum of all such external devices is, for ASCS design purposes a "master sequencer" which coordinates all automatic functions.

The mode-switching section uses compact, solid-state switching circuits. Although these circuits contain many transistors, diodes, and other electrical components, they are of a class that is not critically dependent upon reference voltage or temperature levels.

4-16. Torque Switching Section

The torque switching section contains transistor and diode circuits similar to those in the mode-switching section. Torque switching circuits receive the step-function outputs of the attitude gyro repeaters, plus the outputs of the rate gyros. The latter (rate) signals come from sector switches replacing the usual proportional rate gyro pickoffs. Using these step-wise indications of attitude and rate conditions, along with the mode switching section output defining the current phase of the mission, "decisions" are made which result in energizing of the appropriate Reaction Control valves.

4-17. Accelerometer Switch

The acceleration switch is a hermetically sealed instrument. The basic mechanism consists of a centrally located mass supported by a cantilever spring. The mass is damped by the viscous shear action of the fluid which fills the case. Switch actuation is caused by the displacement of the mass element. An Acceleration force of .05g, in the axis normal to and in the direction away from the base, is required to close the circuit. Mechanical stops are provided to restrain the mechanism and to protect against damage when subjected to excessive acceleration.

4-18. Attitude Gyros

The function of the attitude gyros (vertical and directional) is to determine attitude angles between a set of fixed axes in the moving capsule and the reference axes which are fixed in the orbital plane but which are moving with the local vertical. Both attitude gyros are "free" gyroscopes with slaving capability. A means is incorporated for caging and for obtaining electrical signal (synchros) outputs which define the attitude of the gyros with respect to two mutually perpendicular axes. The attitude gyros possess unrestricted mechanical freedom in the outer axis and $\pm$ 83° (minimum) of mechanical freedom in the inner axis. It is noted that the degree of gyro freedom does not necessarily reflect the attitudes permissible by manually steering the capsule in orbit. Due to limitations in the Horizon Scanner system and the repeater section of the Amplifier Calibrator, manual control of the capsule should be limited to $\pm 30^\circ$ in all axes. However, barring equipment malfunction, exceeding these limits will not prejudice the success of a mission. If these limits are exceeded, it is recommended that the gyro switch be placed in the FREE position. Input power requirements are 115 volt 400 cps single phase (gyro motor), and 26 volt, 400 cps (synchro and torque motor).

4-19. Attitude and Rate Indicator

The Attitude and Rate Indicator is mounted on the upper portion of the Main Instrument panel. The indicator provides visual indications of Capsule Rate and Attitude in the Yaw, Pitch and Roll planes. The attitude indicators are driven by the attitude gyro synchro outputs (through the Amplifier Calibrator). The attitude indicators are calibrated to indicate capsule attitude within a range of $\pm 180^\circ$ except for Yaw which shall indicate 0°, 80°, and 270° in a clockwise direction. The rate portion of the indicator is driven by the miniature rate transducers (See Para. 4-26) which also serve as sensing elements for the Rate Stabilization Control System. The range of rate indication is 0 to $\pm 6^\circ$/sec. for all three indicators. The roll rate indicator has the additional capability of being externally switched to a range of 0 to 15°/sec. in order to monitor re-entry roll rate.

4-20. Rate Gyros

The rate gyros perform electrical circuit switching functions at specific rates of angular velocity about an axis perpendicular to the base of each unit, referred to as the "input axis". Rate gyros are used in the pitch, roll and yaw axes, respectively. Each rate gyro consists of a high speed rotor, mounted in a gimbal ring, in such a manner that it is free to process about one axis only (the output axis) which is perpendicular to the spin axis of the rotor. The output signals are generated by the motion of wipers, attached to the gimbal ring, moving across the contacts of sector switches. Input power requirements are met by 115 volts, 400 cps.

4-21. RATE STABILIZATION CONTROL SYSTEM

4-22. SYSTEM DESCRIPTION

The Rate Stabilization Control System provides an excellent alternate means of capsule attitude control in the event of failure in the Automatic Stabilization Control System. It has been shown by flight simulation studies of the manual control problem that the Astronaut should, by utilizing the Rate Stabilization Control System, be able to approximate retrograde attitude error performance of the Automatic Stabilization Control System. In addition, the Rate Stabilization Control System provides a completely redundant rate-damper and programmed roll rate during re-entry.

The Rate Stabilization Control System consists of three miniature rate gyros, three (signal pickup) potentiometers, three channels of electronics (rate damper) contained in a 300 cubic inch box, one switch, and six solenoid control valves, which utilize the manual reaction control fuel and thrust chambers. Figure 4-1 shows the location of the major components within the capsule. Total weight of the Rate Stabilization Control System is approximately 25 pounds.

Power requirements for the Rate Stabilization Control System are met by 24 volt d-c and 115 volt, 400 cycle a-c. Power is connected directly to the rate damper box through the AUTO/RATE COMD switch mounted on the left console. See Figure 4-12.

4-23. SYSTEM OPERATION

Figure 4-11 is a functional block diagram of the Rate Stabilization Control System. A typical channel is shown. In general, the Rate Stabilization Control System provides the Astronaut with a redundant rate damping and "rate-stick" steering feature. The outputs of the rate transducers and the control stick potentiomenters are combined in the summation networks. The summation networks compare the capsule's angular rate errors and, if errors exceed preset dead-zones, 2 deg/sec in Roll and 3 deg/sec in Pitch and Yaw, the appropriate off-on corrective torque is commanded by energizing solenoid control valves in the Manual Reaction Control System. With the control stick at zero deflection (Rate Stabilization Control System operational) an automatic three axis rate-damper is achieved, including an automatic 7.7 ± 2 deg/sec constant roll rate when re-entry is sensed. By manipulation of the control stick, steady-state angular rates other than zero (approximately proportional to stick deflection) may be attained if desired. This is in contrast to the proportional acceleration (Torque) response which remains as an alternative in event of malfunction in the Rate Stabilization Control System.

4-24. SYSTEM UNITS

4-25. Rate Damper Box

The rate damper box provides three channels of transistorized electronic unit comprising the rate-damper portion of the Rate Stabilization Control System. Each channel contains a summation network, preamplifier and demodulator, and two trigger circuits. The $5\frac{1}{2}$ x 6 x 9 in. box weighs approximately seven pounds and is mounted below and immediately aft of the control stick. The rate-damper box mounts two AN type electrical connectors, one for GSE and one for capsule interconnection. The dead band adjustments which are provided are a 2 deg/sec to 4 deg/sec in pitch and yaw axis and a 1.5 deg/sec to 3 deg/sec in

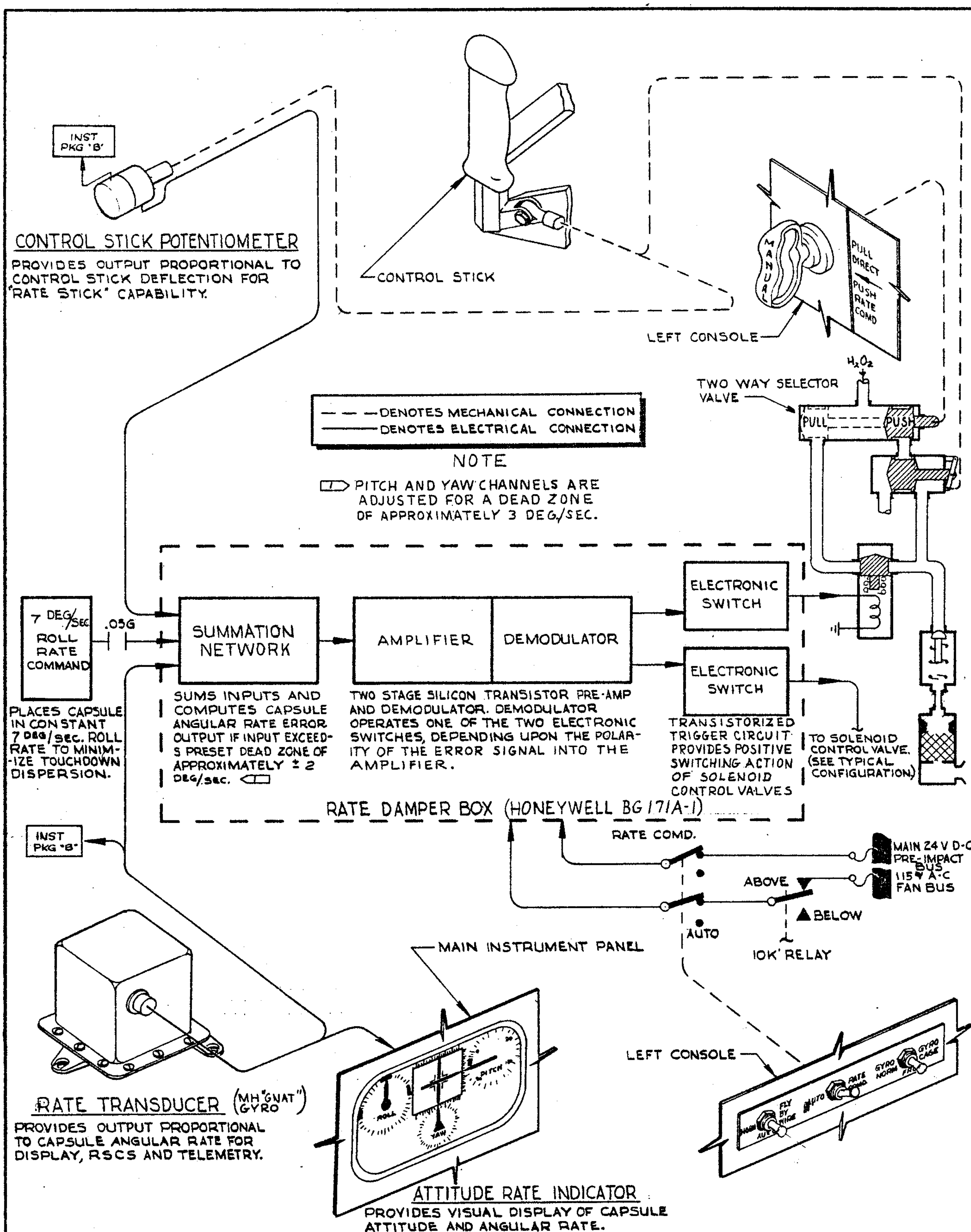


FIGURE 4-11 RSCS BLOCK DIAGRAM

PM45-1388

the roll axis. Signals from the rate transducers and stick potentiometers are sent to the rate damper box where the two signals are summed together forming an error signal. The error signal is sent to a two stage voltage amplifier followed by a double ring diode demodulator. In accordance with the magnitude and phase of the error signal the demodulator will select one of two transistor operated relays which applies a 24 volt d-c output signal to appropriate solenoid control valve such that corrective torque is applied.

4-26. Miniature Rate Transducers

Each of the miniature rate transducers consists of a gyroscope, an amplifier, and a demodulator. These components function together to produce an a-c output signal proportional to input rate of change of attitude. All three rate transducers are identical except for gyro orientation in the transducer base. A special indexing feature prevents installation in the wrong location. Input power utilized by the rate transducers is 115 volts, 400 cycle a-c.

4-27. Control Stick Potentiometers

The three identical 1000 ohm 120 turn potentiometers are connected to the manual control stick linkage in such a manner that output signals are produced proportional to stick deflection in the yaw, roll, and pitch planes. Active sector is equal to 40 degrees with a minimum of 10 degrees of over-travel without electrical discontinuity.

4-28. REACTION CONTROL SYSTEM

4-29. SYSTEM DESCRIPTION

The Reaction Control System is used for capsule yaw, pitch and roll control. The system is a pressure fed monopropellant, catalyst bed design. The right angle thrust chambers obtain thrust by decomposition of 90% hydrogen peroxide (H_2O_2). The system is divided into two individual systems; one for automatic control (ASCS), and one for manual control (control stick and RSCS). The auto-

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

CONFIDENTIAL

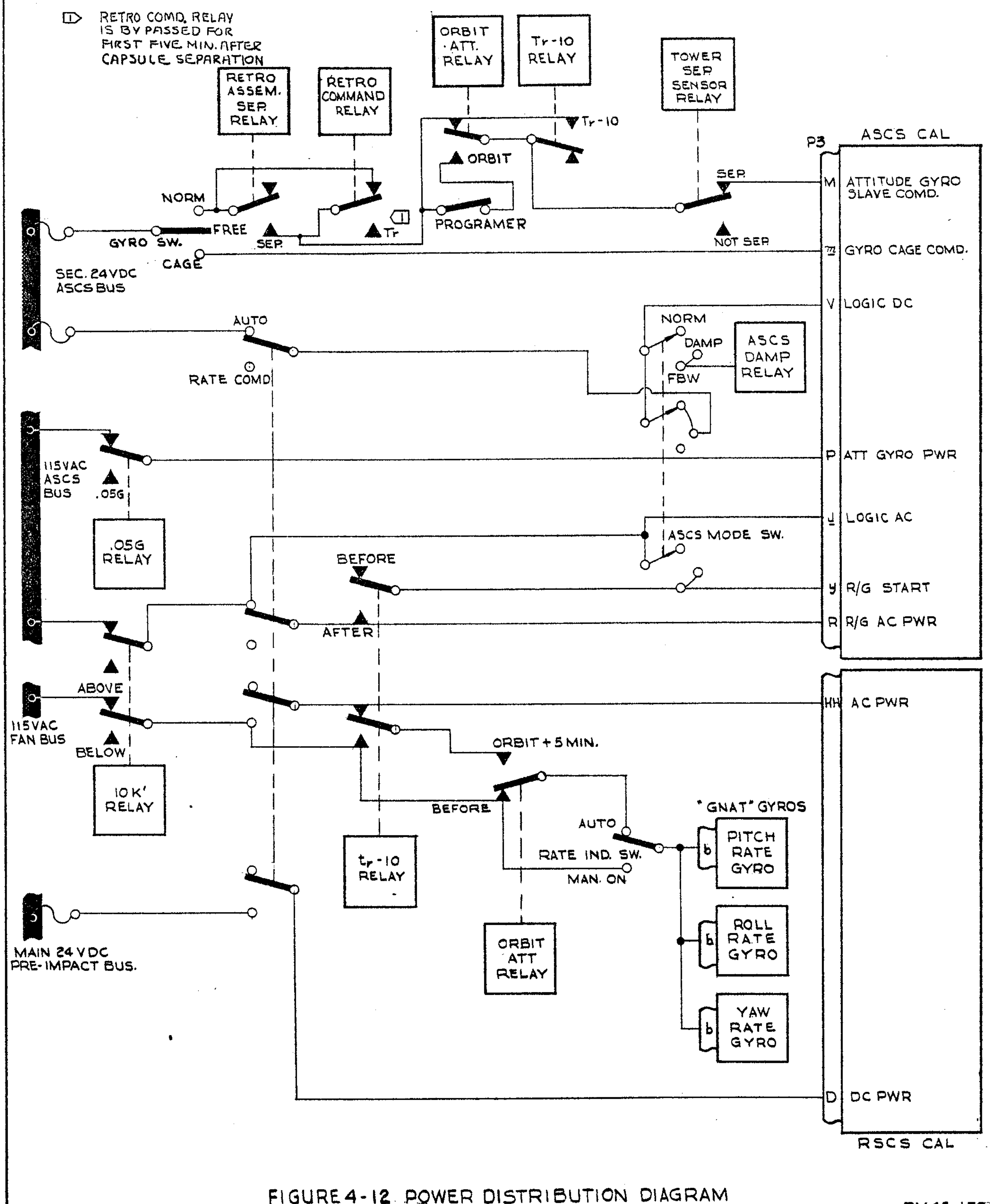


FIGURE 4-12 POWER DISTRIBUTION DIAGRAM

CONFIDENTIAL

matic system consists of a pressurization system, an "electrically" controlled solenoid fuel distribution system, and twelve thrust chambers. The manual system is similar to the automatic system except that it consists of only six thrust chambers. The manual system also utilizes proportional "manually" controlled fuel distribution valves in addition to the electrically operated solenoid control valves. Figure 4-13 shows the location of all system components within the capsule.

4-30. SYSTEM OPERATION

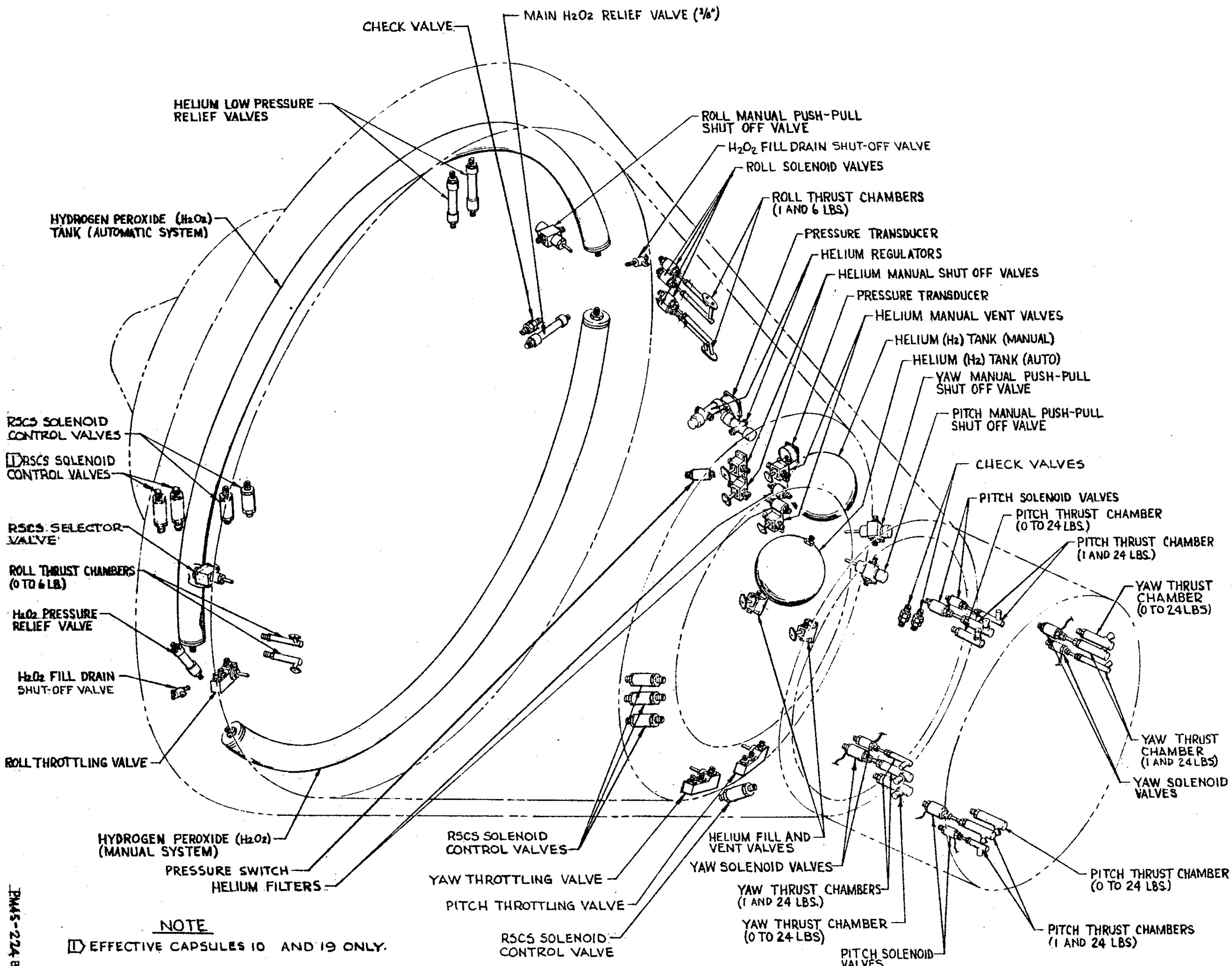
The following paragraphs, 4-31 through 4-35, briefly describe the operation of the automatic and manual systems. Figure 4-18 and 4-19 should be followed closely in conjunction with the following text.

4-31. Automatic System

The automatic system consists of twelve hydrogen peroxide monopropellant thrust chambers of fixed thrust levels and their associated valves, lines, H_2O_2 tank, pressure regulator and pressurization bottle. (See Figure 4-14.) The automatic system can be essentially divided into three sections; pressurization and fuel supply, distribution, and propulsion units. The fuel supply is unstable hydrogen peroxide (H_2O_2) contained inside a flexible bladder which in turn is contained in a half toroidal tank. The flexible bladder has a fuel capacity of approximately 32 pounds of liquid H_2O_2. Helium, under pressure, surrounds the bladder containing the H_2O_2 and acts as the pressurization agent. The Spherical helium tank, pre-serviced to 2250 psi, has a capacity of 265 cubic inches.

The following sequence of events occurs in producing a thrust output. Assume the bladder is serviced with H_2O_2 and the helium sphere pressurized to 2250 psi. Upon opening the helium regulator manual shutoff valve, helium is allowed to pass through the filter, regulator, checkvalve, and finally surrounds

CONFIDENTIAL



NOTE

1 EFFECTIVE CAPSULES 10 AND 19 ONLY.

FIGURE 4-13 REACTION CONTROL SYSTEMS

CONFIDENTIAL

the bladder pressurizing it to 480 psi. The helium pressure forces the H_2O_2 out of the bladder through the perforated transfer tube and into the down-stream lines. By opening the manual push-pull shutoff valves the H_2O_2 becomes available at the "electrically" operated solenoid shutoff valves. Upon receiving a 24 V d-c signal from the ASCS or fly-by-wire control system, the appropriate solenoid valve opens. H_2O_2 enters the solenoid valve through an integral 165 micron filtration screen and passes into the corresponding thrust chamber where it is decomposed and produces the desired thrust. See Figure 4-20.

System components not directly associated with the preceding explanation of a thrust output are explained as follows. The helium pressure transducer provides a means of monitoring (by proper calibration) the percentage of H_2O_2 present in the bladder. The perforated tube in the propellant tank (external of the bladder) is used to prevent the possibility of trapping helium pressure while servicing the H_2O_2 bladder.

4-32. Manual System

The manual system (See Figures 4-15 and 4-16) consists of six thrust chambers of the same configuration as those in the automatic system with proportional thrust output added. The fuel flow in the manual system may be controlled in either of two ways: (1) by manually controlling the proportional control valves, or (2) by electrical solenoid control valves. A two position selector valve is provided such that the method of control may be selected. See Figure 4-19. The manual control valves have a dead band of ± 1/16 of an inch from theoretical neutral and a total stroke of 3/8 of an inch from theoretical neutral for each thrust chamber. The throttle valve arm assemblies or bellcranks which rotate these proportional control valves are designed to shear at less than full Astronaut effort on the manual control system. See Figure 4-29. In the event a proportional control valve should jam and immobilize

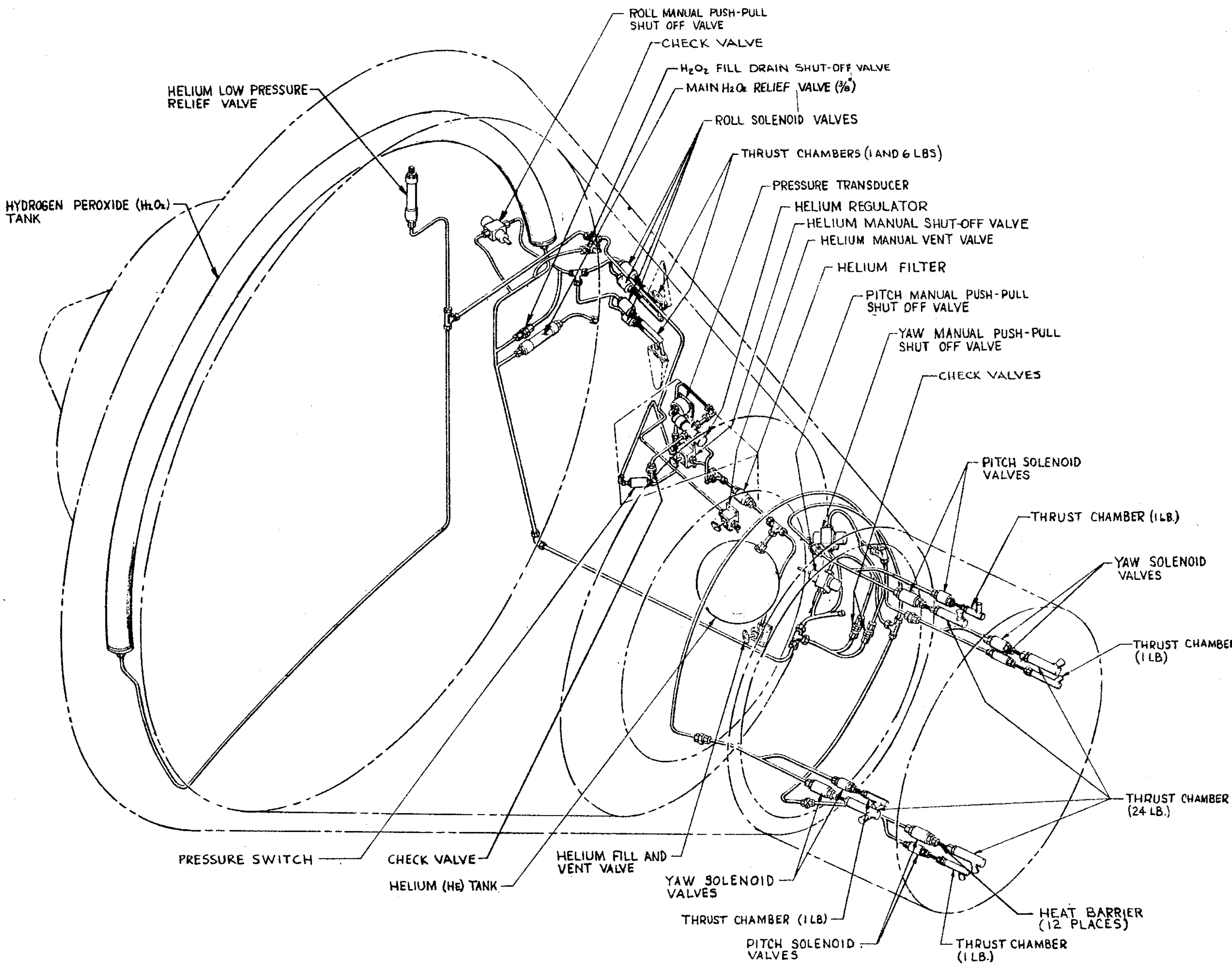


FIGURE 4-14 AUTOMATIC RCS INSTALLATION

~~CONFIDENTIAL~~

CONFIDENTIAL

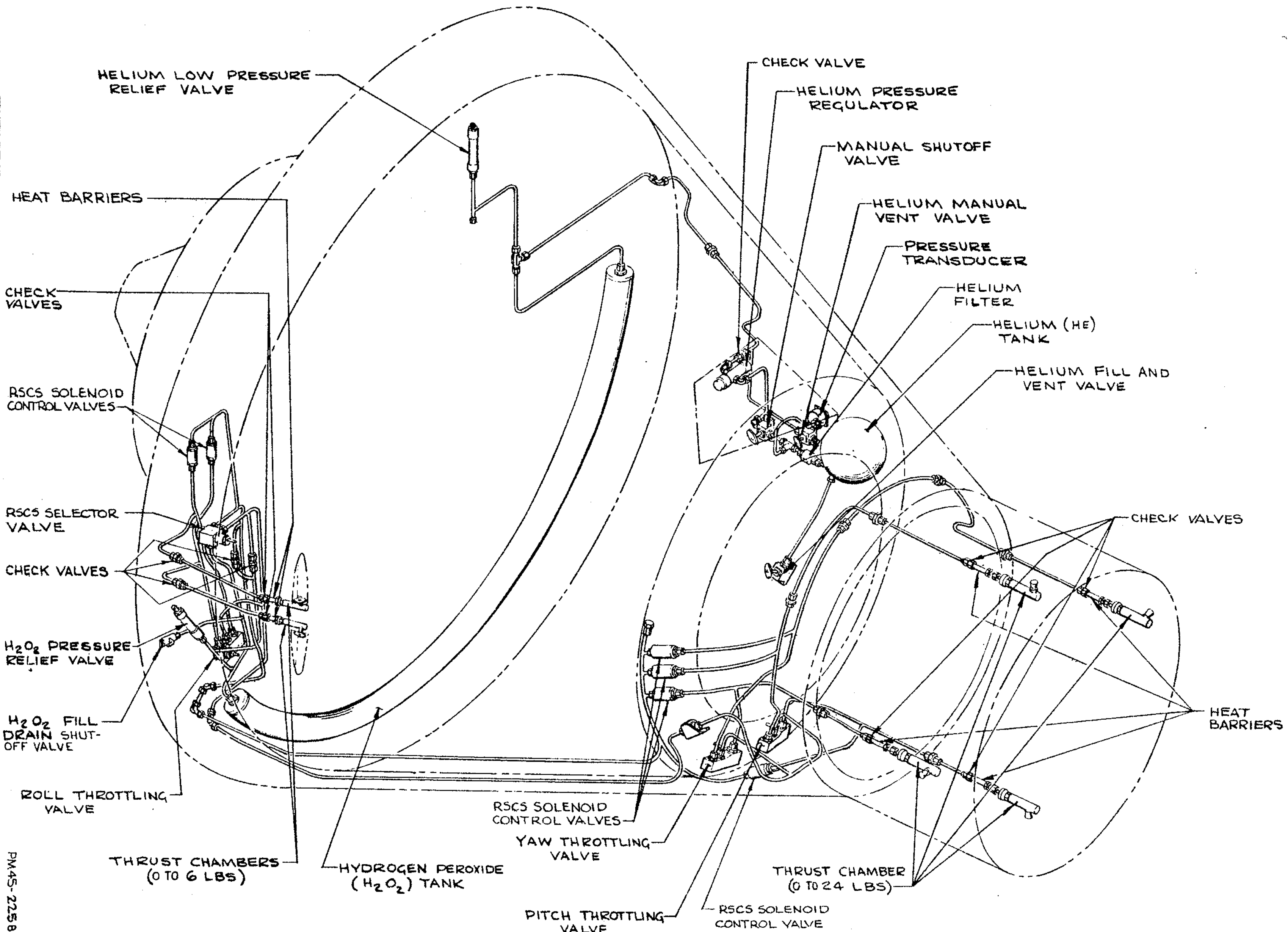


FIGURE 4-15 MANUAL RCS INSTALLATION

PM45-225B

CONFIDENTIAL

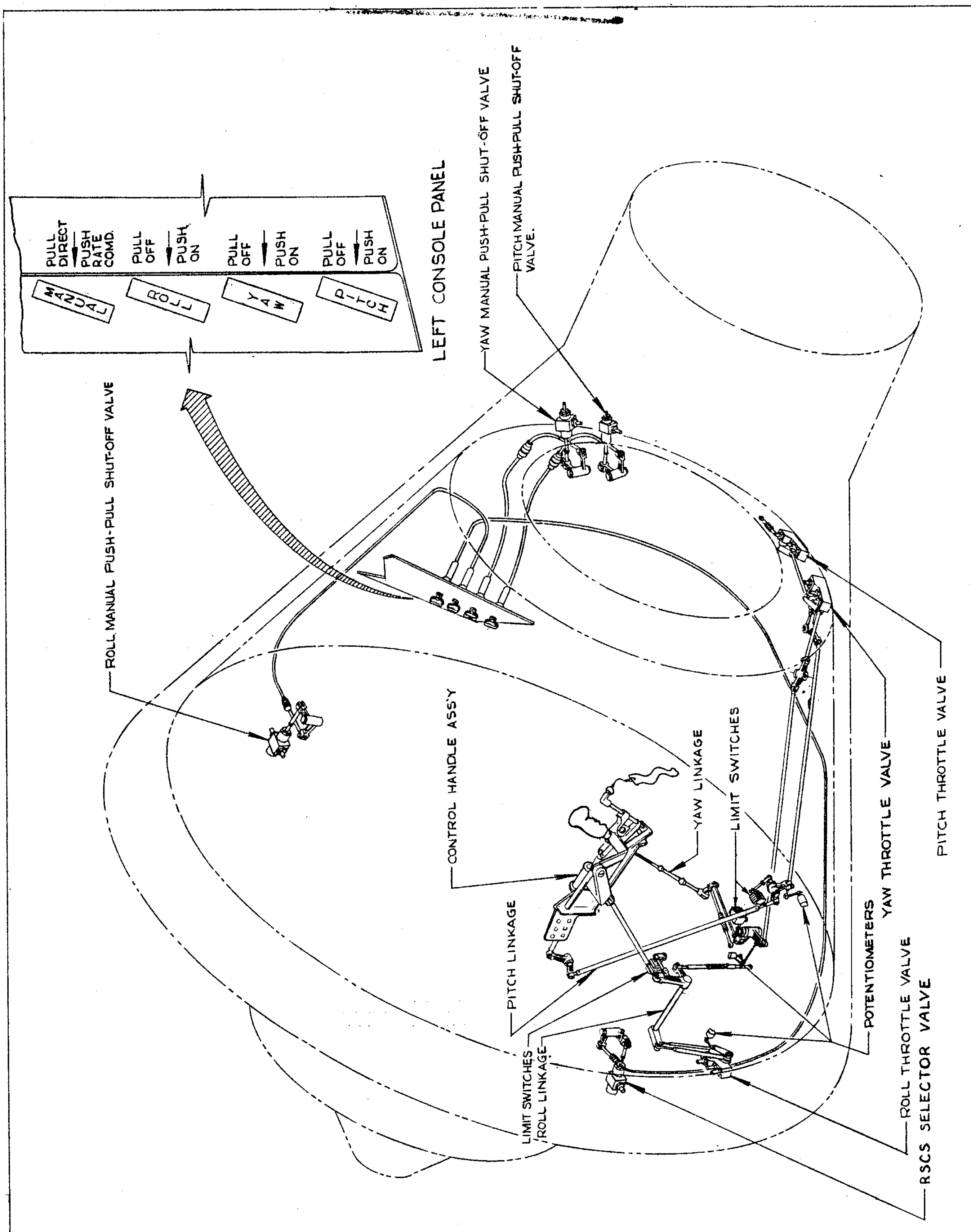


FIGURE 4-16 RCS CONTROL LINKAGE

PM45-52C

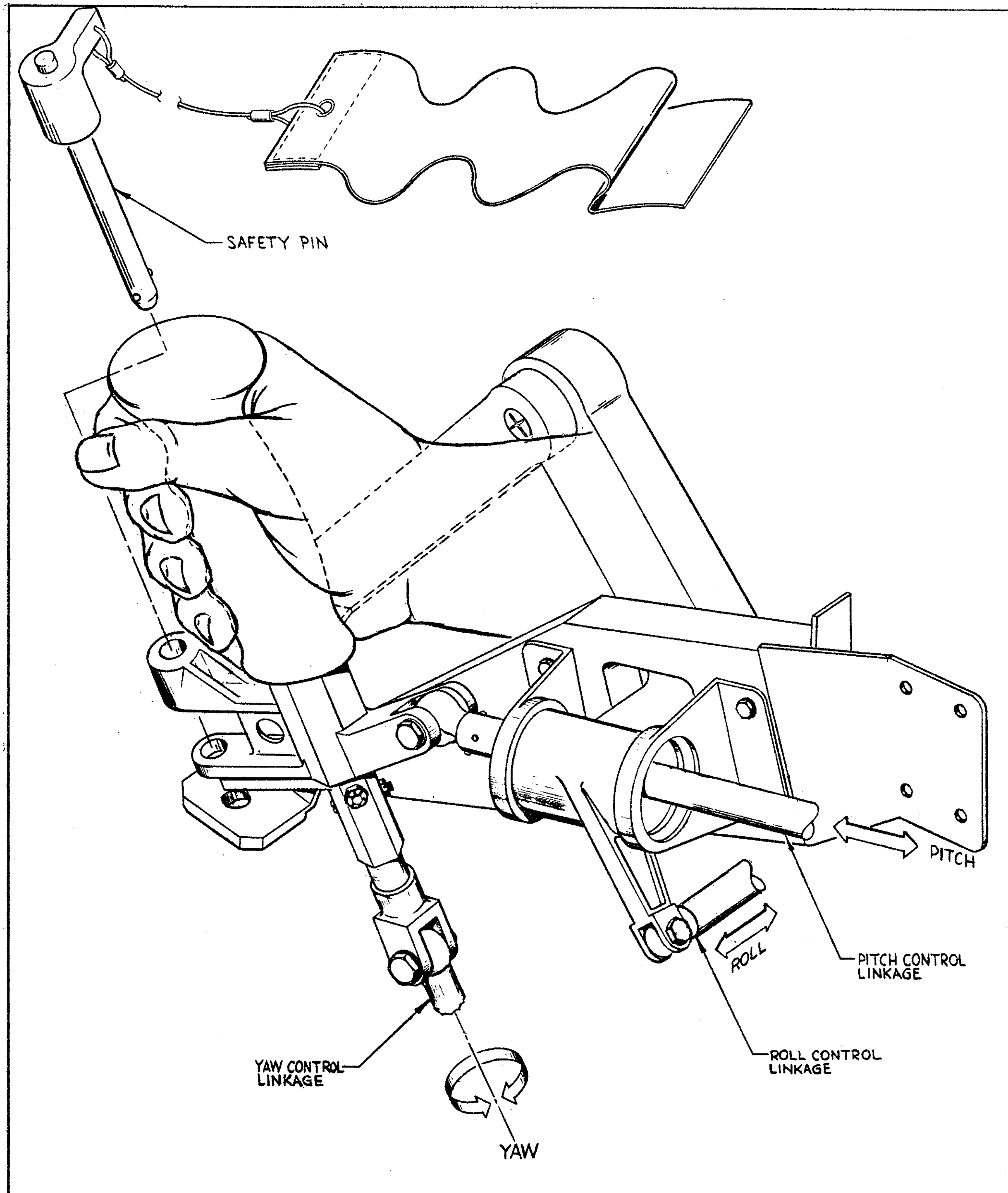


FIGURE 4-17 THREE AXIS HAND CONTROLLER

PM45-54-A

the manual control system in one axis, increased Astronaut effort would break the shear pin in the bellcrank and free the system. The manual control system could then be utilized for automatic control system fly-by-wire switch operation or manual control system "rate stick" potentiometer deflection. See Figures 4-9 and 4-11. The remainder of the manual control system is similar to the automatic system except for fuel capacity, which is 23.4 lbs. of H_2O_2 for the manual system.

4-33. SYSTEM UNITS

Due to the simple nature of the system components, a discussion of each is considered unnecessary. However, two items (thrust chambers and propellant fuel) do warrant brief explanations.

4-34. Propellant Fuel (H_2O_2)

Hydrogen peroxide is a clear, colorless liquid soluble in all proportions in water and most substances which are miscible with water. Hydrogen peroxide when catalytically decomposed releases water vapor, oxygen gas, and heat. H_2O_2 decomposition when properly contained and controlled is capable of producing usable thrust. One pound of H_2O_2 solution (90%) when properly decomposed will produce approximately 60 cubic feet of gas. Hydrogen peroxide (90%) freezes at 11.3°F, and boils at 286°F.

4-35. Thrust Chamber

The thrust chamber assemblies (See Figure 4-20) consist of a stainless steel chamber that contains a metering orifice, a distribution disc followed by a catalyst bed and then a nozzle. The catalyst bed contains a stack of removable nickel screen wafers. The screen gauge resembles common household screen. The screen is covered with an electrolytically deposited coating of 99% silver and 1% gold (called drexite) that enhances the catalytic properties of the nickel. The open area between the catalyst bed and the right angle nozzle forms a short

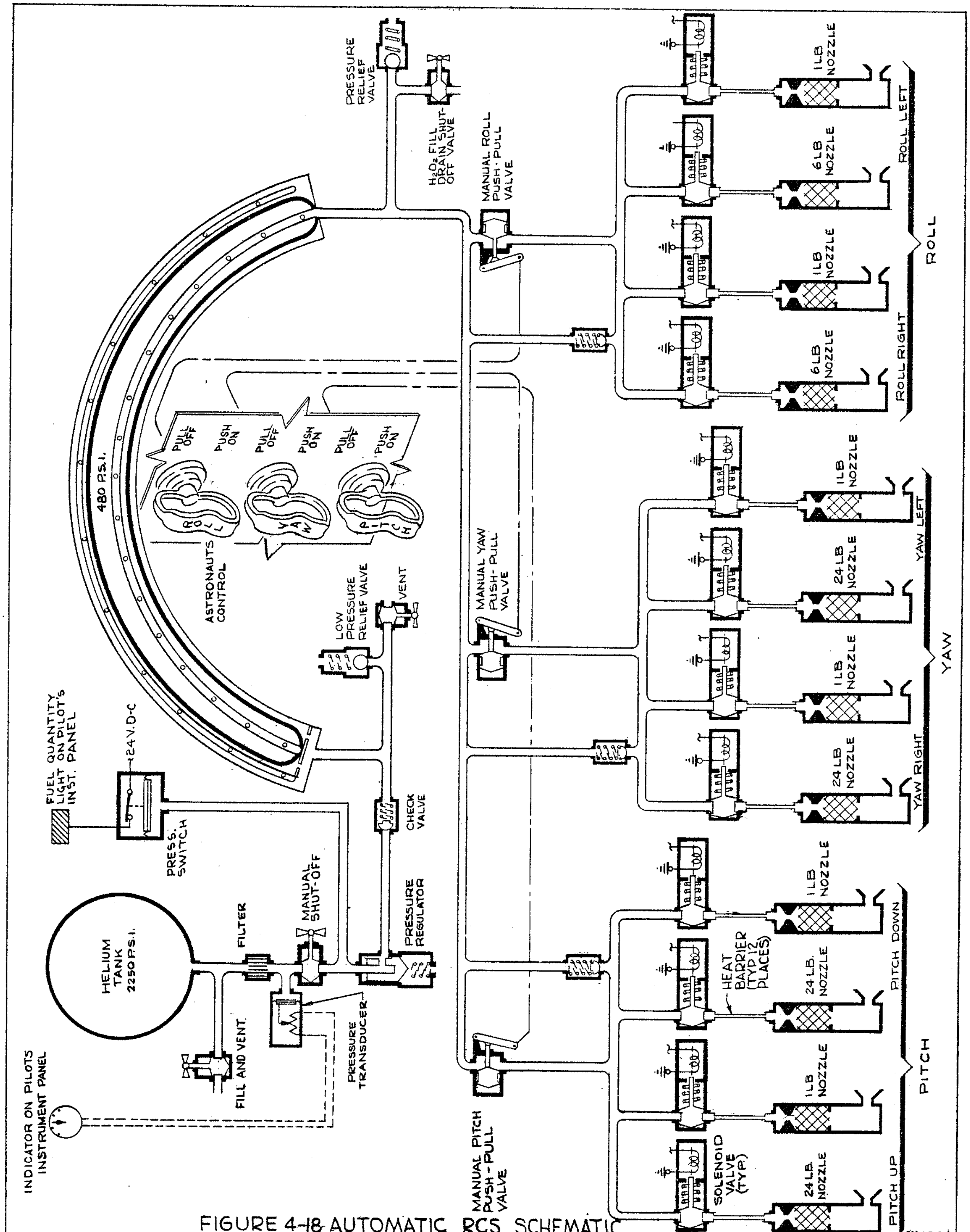


FIGURE 4-18 AUTOMATIC RCS SCHEMATIC

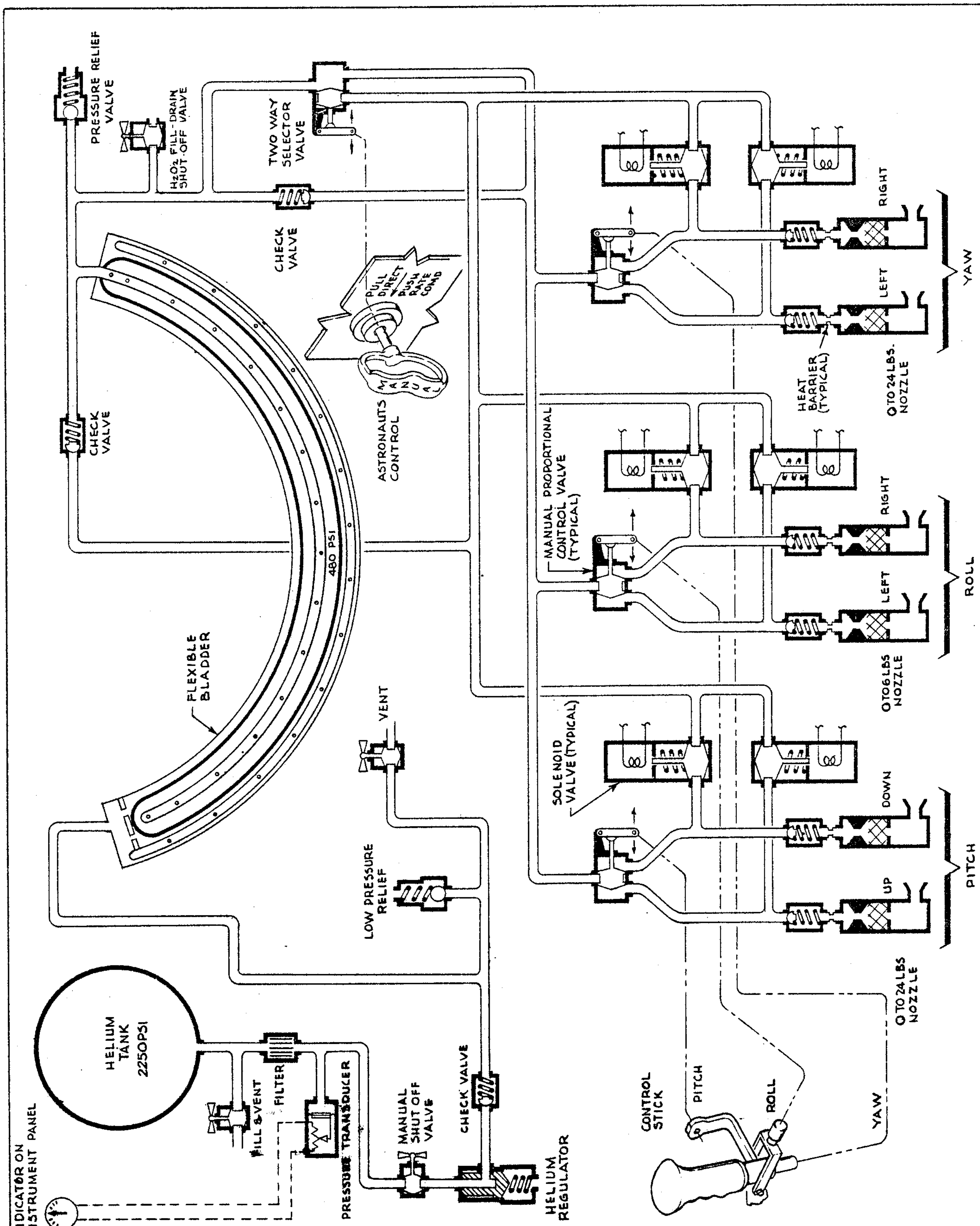
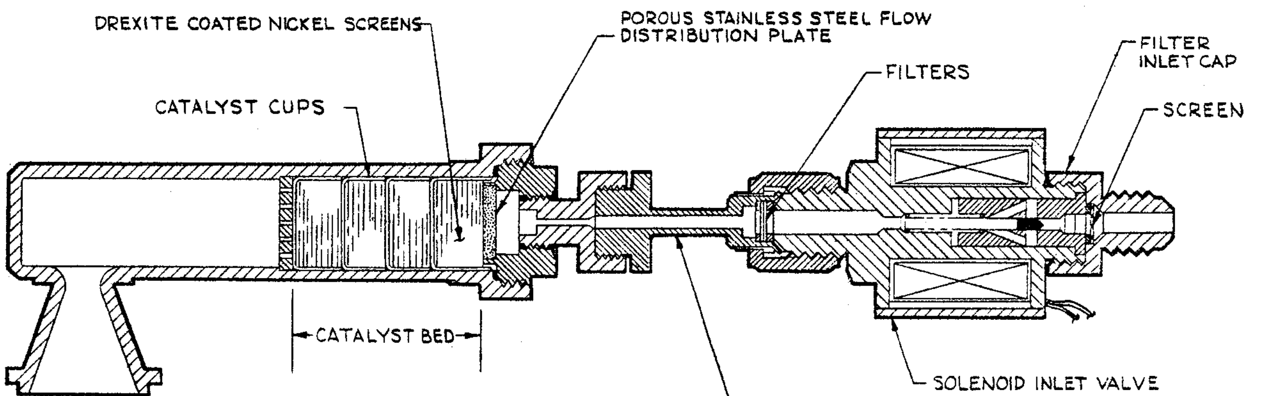
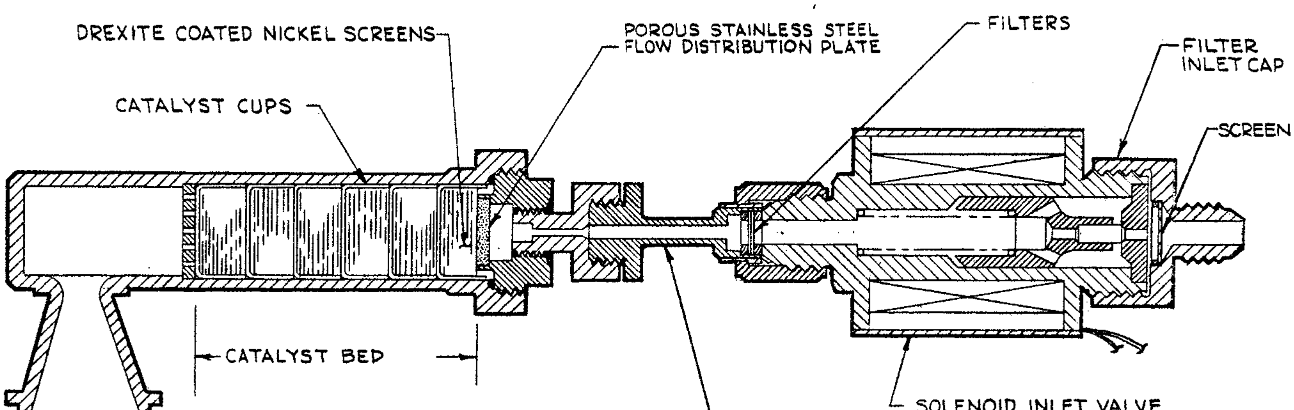


FIGURE 4-19 MANUAL RCS SCHEMATIC DIAGRAM

PM45-140C



1 LB. AND 6 LB. THRUST



24 LB. THRUST

FIGURE 4-20 REACTION CONTROL THRUST CHAMBER

PM45-51B

plenum chamber to smooth out the flow prior to reaching the nozzle throat.

H_2O_2 enters the thrust chamber through a metering orifice upon actuation of the solenoid valve. The stainless steel porous plate distributes the flow and presents the catalyst bed with a uniform input. Upon entering the first stage of the catalyst bed, a violent reaction takes place. Expanding gases rush through the remainder of the catalyst bed resulting in a thrust output in the right angle nozzle. The majority of the decomposition (and most violent) takes place within the first two catalyst cups. Temperatures of approximately $1400^{\circ}F$ can be expected in this area. The remainder of the catalyst cups are to assure a complete decomposition process and to prevent any liquid form of H_2O_2 from reaching the nozzle.

4-36. HORIZON SCANNER SYSTEM

4-37. SYSTEM DESCRIPTION

The Horizon Scanner System incorporates two identical scanning units. The purpose of the Horizon Scanner system is to provide a roll and pitch reference during the orbital phase of the normal mission. The scanners produce an output signal that slaves the ASCS attitude gyros to the proper angles upon command from an external programmer.

4-38. Basic Construction

Figure 4-21 is a photograph of a Horizon Scanner Unit. All major components and subassemblies are mounted from the large circular plate and include the scanning prism assembly, prism drive system, infrared detector, electronics, synchronous switches, electrical connector and cover. The circular plate is flange mounted so that the scanning prism compartment projects into the space outside of the vehicle. The elctronics system is completely transistorized and the various functional sections are fabricated on separate printed circuit boards. Three of these printed circuit boards are enclosed in the shielded housing fastened to the circular plate. The remaining boards are fastened to the four posts mounted on the circular plate. For rapid servicing the four posts with attached boards can be replaced as a single unit, or individual boards can be replaced as required.

4-39. Special Features

The Horizon Scanner has a number of special features. It is compact in size (6 5/32" long x 5 7/8" diameter over-all) and light in weight (3.02 lbs). The scanner is equipped with a centrifugally - activated shutter. The shutter prevents solar radiation from dwelling upon the detector and resulting in probable damage during those periods when the scanning prism is not rotating. Another feature is a special circuit which can be used to disconnect the error signals from the vehicle reaction devices during those periods when the presence of the sun in the scan path or the loss of horizon would result in erroneous error signals. The final feature of significance is that only a single power source providing 110 volts, 400 cycles, 3.2 va is required to operate the entire system. The highly regulated power supply in the system eliminates the need for the bulky batteries usually required to bias the infrared detector.

4-40. SYSTEM OPERATION

Operation of the Horizon Scanners depends upon infrared radiation received from the earth as compared to the essentially zero radiation from space. These differences in radiation levels provide a sharp radiation discontinuity at the horizon. The Scanner system uses this discontinuity for both day and night vertical reference sensing. When the capsule is oriented so that the earth is present in its scanning path, there will in general be two points where the scan intersects the earth's horizon (See Figure 4-22). The scanner detects the thermal discontinuity, or change in radiation level, between the earth and

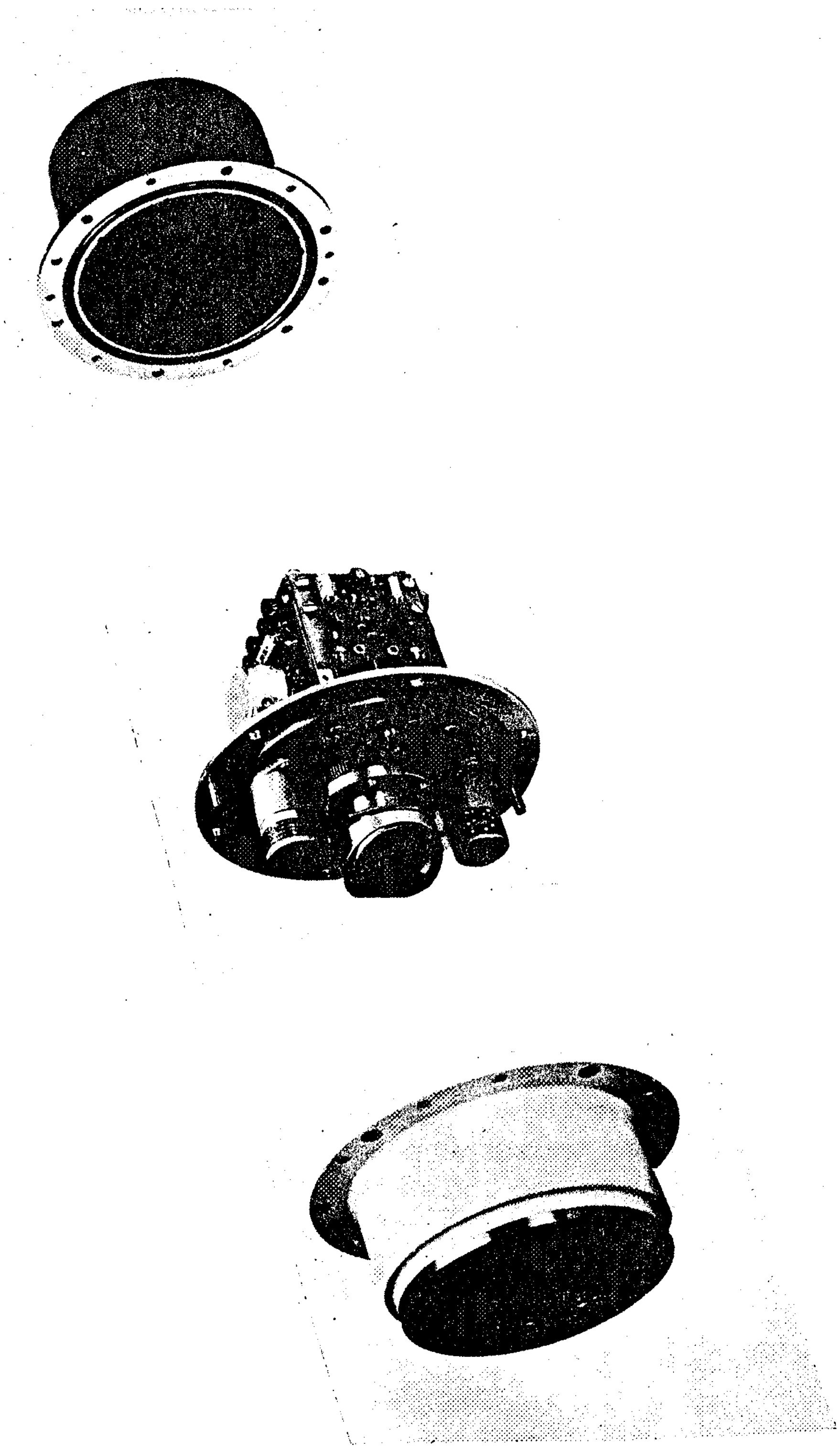


FIGURE 4-21 WIDE ANGLE HORIZON SCANNER

PM45-218 A

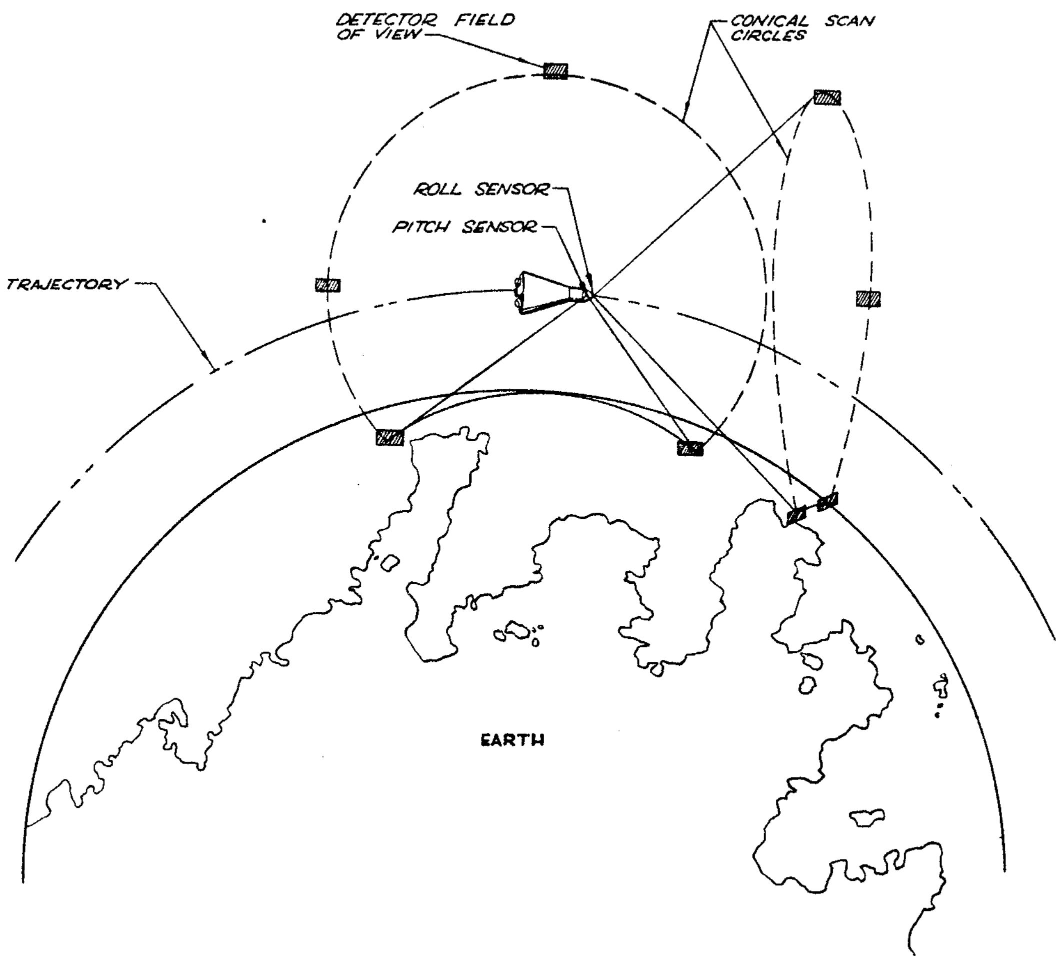


FIG. 4-22 HORIZON SENSOR SCAN PATTERN

space at the two horizon points. The Scanner then bisects the included angle from itself to the Horizon points, compares the direction of the bisector with that of a fixed reference in the capsule and generates linear error signals proportional to the angle between the bisector and the fixed reference. As previously stated, these error signals (roll and pitch) are used to slave the ASCS attitude gyros.

Figure 4-23 shows a simple block diagram of the Horizon Scanner. The following discussion entails a brief explanation of the functioning of each block as related to the over-all operation.

4-41. Radiation Gradient At Horizon

There is a large difference in the radiation which the detector receives as it scans across the boundary between space and the upper atmosphere (troposphere). This change is approximately equal to that from black bodies at $0^{\circ}K$ and $200^{\circ}K$ respectively, and the radiance difference is approximately 0.003 watts/cm^2 - steradian. The location of this gradient is sharply defined, and it is much larger than any others that can be encountered during the scan cycle.

4-42. Correction For Reflected Solar Radiation

Sharp radiation gradients do exist because of reflected solar radiation. Such gradients are found at cloud edges, topographical irregularities on the earth's surface and the terminator line between night and day. These radiation changes can be filtered out so that the horizon gradient is the only one that is detected by the system. Selective filtering can be accomplished since most of the reflected solar radiation falls in the spectral region between 0.2 and 2.0 microns, while the radiation emitted by the earth and troposphere is at wavelengths longer than 5 microns. The filtering is accomplished by a germanium prism and field lens in front of the detector. As a filter, germanium sharply cuts off all radiation at wavelengths shorter than 1.8 microns while transmitting very uniformly radiation from 1.8 to 20 microns. The use of this filter removes over 90 percent of the reflected solar radiation. Signal clipping techniques in the electronics remove any residual effects.

4-43. Scanning and Radiation Detection

Details of the scanning prism assembly can be seen in Figure 4-21. The infrared detector is fixed to the center of the circular plate and its field of view extends through the circular opening in the center of the scanning assembly. The detector field of view is 2^{o} by 8^{o} and the presence of the scanning prism has the effect of deflecting it 55^{o} from the normal. Thus the apex angle of the scanning cone is 110^{o}. In operation, the drive system rotates the scanning prism and the detector field scans the field of view through the conical pattern described previously. Different amounts of radiation strike the detector during various portions of the scan cycle, and the amplitude of the detector output changes accordingly. The detector output signal is processed by the electronics system and the error signal produced is available at the electrical connector.

4-44. Synchronizing Generator

Closely associated with the prism drive system is the reference signal generator. The output of this generator is a square wave signal at a frequency of 30 cycles per second. This signal is the fixed reference against which the detector horizon signals are compared. The reference signal is triggered by the interaction between a magnetic pickup coil and a semi-circular steel vane. The vane is imbedded in a slot cut into the surface of the scanning prism assembly gear. A pickup is mounted so that the end of its magnetized core comes close to the surface of the vane. As the scanning prism assembly turns, the ends of the vane pass by the end of the magnetized pickup coil core, generating the reference pulse. A subsequent electronic network converts the pulse to a phase locked 30 cycle square wave. The use of this signal will be considered later in this section.

4-45. Sun Shutter

The sun shutter consists of a pair of spring loaded metal slides which fit into opposed transverse slots through the tube section of the scanning mirror assembly. When the scanning mirror assembly is not rotating spring tension pulls the two slides together and the detector field is obstructed. When the scanning mirror is turning, the centrifugal force on the slides is sufficient to open the shutter.

4-46. Infrared Arrangement

Infrared radiation from the field of view strikes the infrared detector and produces the electrical signal which is processed by the electronics system. The infrared detector is a thermistor bolometer with its active element immersed in the germanium lens.

The active element is a rectangular flake of thermistor material and is connected in a bridge circuit with a similar compensating flake which is shielded from radiation. The two flakes are oppositely biased and their junction is connected to the input of the preamplifier which follows. By immersing the active element in the rear surface of the germanium lens the over-all detectivity can be increased by a factor of about 3.5 over an unimmersed detector having the same field of view. The material in the thermistor flake has a high negative temperature coefficient of resistance. That is, when the temperature of the material is raised, the flake resistance decreases. Since the surface of the thermistor flake is blackened, it absorbs impinging radiation and its resistance is decreased. When the shutter is closed, both flakes in the detector bridge are at the same temperature. Since both flakes have the same linear characteristics, their resistances are the same. Gradual variations in ambient temperature change the resistances of both flakes by equal amounts and the voltage of their junction remains the same. When the shutter opens, incoming radiation is focused on the active element; the compensating element is shielded from outside radiation. The temperature of the active element is changed, and its resistance becomes different from that of the compensating element. As a result, there is a voltage change at the junction of the two flakes and this change is connected to the electronics system. As the scanning prism turns and causes the detector field of view to cross the horizon, there is a sharp change in the radiation level striking the detector. The result of the radiation changes during a complete scan cycle is the generation of an approximate square-wave signal at a frequency of 30 cycles per second.

Electronics system is physically arranged so that functionally related parts are located close to each other. The electronics system is divided into eight major circuits, located on individual printed circuit boards. In some cases, the requirements of compact and economical construction have resulted in two or three sub-circuits being located on one board. Thus, the functionally related booster amplifier, signal centering circuit and phase inverter-limiter are located on one board which the block diagram (Figure 4-23) shows as divided by dotted lines. Although the power supply and reference generator circuits are not closely related in function they are both located on the same printed circuit board.

The paragraphs that follow describe the functions of the major sections and sub-sections of the electronics system. The description is made with reference to the waveforms generated by system operation, and these are shown in Figure 4-24. Functional description will be made at the level of the major circuits and sub-circuits shown in the block diagram Figure 4-23.

4-47. Immersed Detector

The radiation falling upon the detector determines the waveshape of the detector output signal which is to be processed by the electronics system. The radiation characteristics are determined by the scanning cycle described previously, and are shown as the first waveform, WF-1, of Figure 4-24. The waveform shows that earth radiation is higher than space radiation and that there is an abrupt shift from one level to the other as the detector scans across the horizon. The change in radiation requires 200 microseconds to take place because the detector is of finite size, and this time is required for a complete shift of radiation level across the entire surface of the detector. Thirty complete cycles of radiation change take place in one second.

WF-2 shows the detector output signal which results from the radiation changes taking place at the detector. This signal resembles the radiation signal with the exception that the shift between the two levels takes a longer time. The reason for this is that approximately 2 milliseconds is required for the active detector flake to reach the half-level of its now stabilized output. The detector output signal has an amplitude in the order of 2 millivolts.

4-48. Pre-Amplifier and Booster Amplifier Circuits

The junction of the two thermistor flakes is direct-coupled to the input of the pre-amplifier. The pre-amplifier has a voltage gain of 400 at 30 cycles per second. Direct-coupling is used between pre-amplifier stages to provide good low-frequency response and to prevent phase shift. Negative feedback is used within the pre-amplifier to provide stable gain, and the RC coupling network in the feedback loop provides a high-frequency boost to compensate for the long detector time constant. WF-3 shows the effect of this boost. The rise time of the waveform has been reduced to approximately 350 microseconds at the half-level point. The booster amplifier provides an additional voltage gain of 5 at 30 cycles per second. WF-4 shows the output of the booster amplifier. The peak-to-peak signal amplitude is in the order of 5 volts.

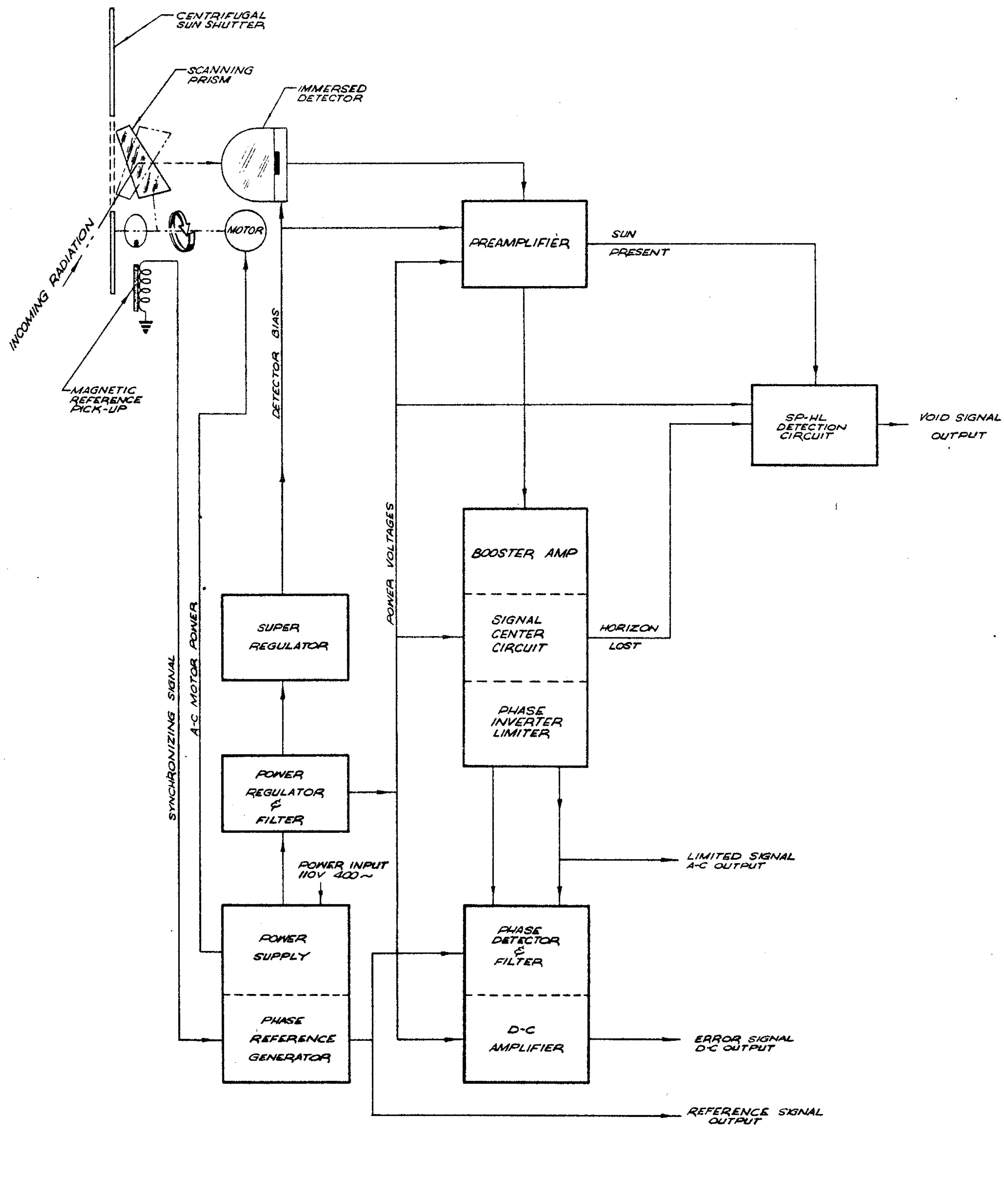


FIG 4-23 HORIZON SCANNER BLOCK DIAGRAM

PM 45-53 B

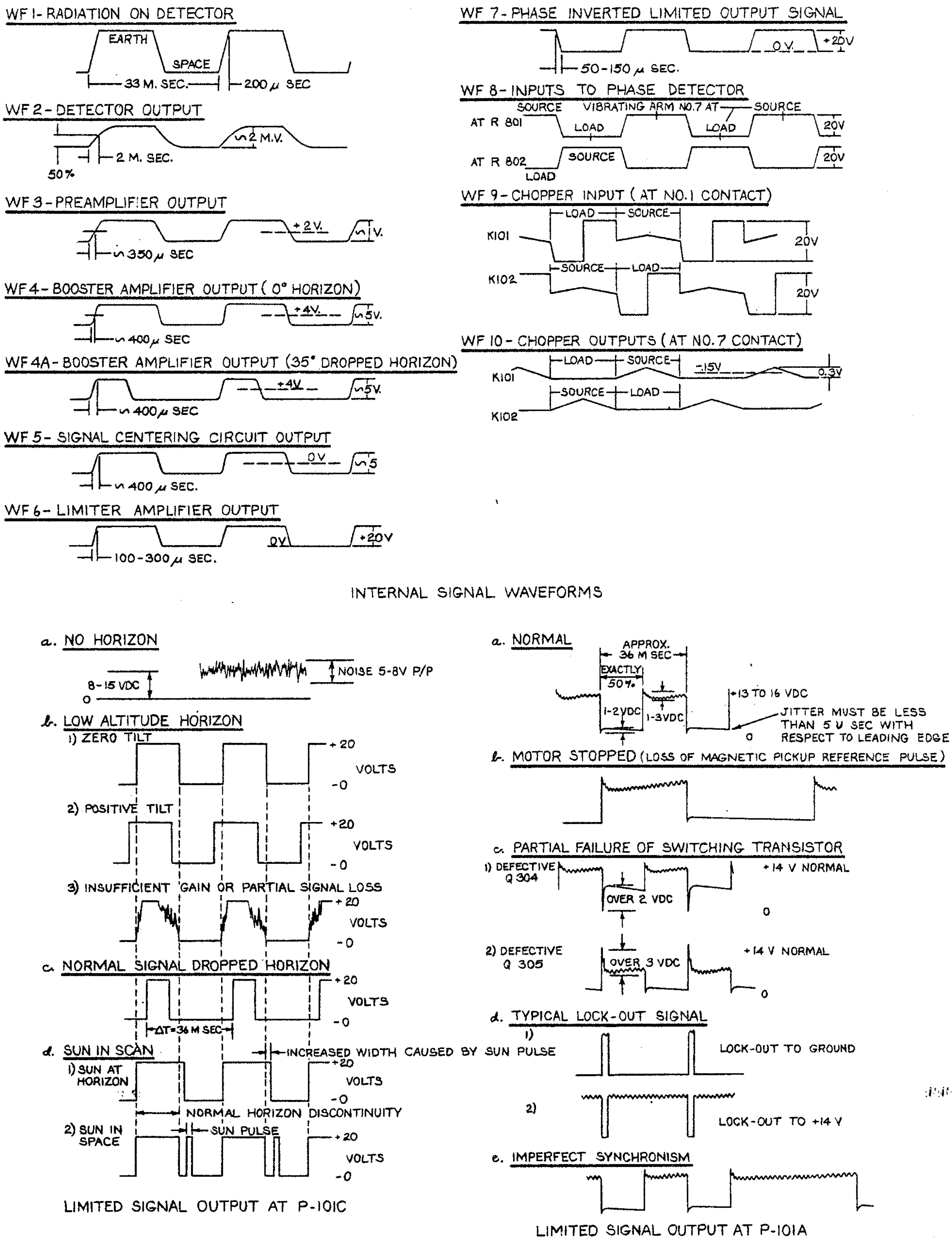


FIG. 4-24 HORIZON SCANNER WAVE FORMS

4-49. Signal Centering Circuit

In the signal processing considered previously there has been no particular interest in the voltage level of the average signal. However, this average signal level is important in system operation. The reason for this is that the error signal must be determined only by the phase angle between the horizon and the fixed reference in the vehicle, and amplitude variations in the signal should have no effect. Amplitude variations will take place because of changes in earth temperature at different parts of the trajectory or orbit. When these amplitude variations are combined with the rise-time characteristic of the detector there is a difference in phase between different portions of the leading edge and the fixed reference signal. Error signals would also be affected by amplitude changes due to changes in amplifier gain and supply voltage. Limiting can be used to eliminate the amplitude variations but the limiting slice must be taken at a point of minimum phase variation. These variations are greatest at the peaks of the wave and least at the center. Using an RC circuit to couple the signal to the limiter would balance equal areas of the signal waveform above and below ground. Changes in the angle of horizon depression would cause a shift in the d-c level of the signal. Hence, a signal centering circuit is employed before the limiters to assure that the same center slice is sampled for phase shift under all conditions. The signal centering circuit consists of two diodes connected back-to-back as d-c restorers. The diodes conduct on opposite peaks and thus permit the associated capacitors to charge up to opposite peak values of the signal. The two levels are then summed in a resistive divided network, and half the sum is sampled by tapping the divider at its midpoint. An emitter follower couples this signal which is shown in WF-5 to the limiter circuit.

4-50. Limiting and Phase Splitting Circuits

The signal next enters the first of a pair of cascaded feedback amplifiers, each of which acts as a limiter and phase inverter. The amplifier consists of a grounded emitter stage which performs the phase inversion, and an emitter follower. The feedback ratio is about 50:1 and the over-all gain of the section is about 30. The output swing is 10 volts each side of the fixed 10-volt level. A low output impedance is maintained during the time when the emitter follower is in cutoff by feeding the signal from the collector of the grounded emitter stage directly through a shunt diode. The first section of the feedback amplifier is fed by the signal centering circuit. Its output signal is the "limited signal output" and shown in WF-6. Part of this signal is fed to another limited amplifier substantially the same as the first, where it undergoes a second inversion to become a mirror image of the output of the first section. The output of the limiter section is thus the dual signal shown in WF-8. While either signal carries the signal information, the presence of the image signal will be found useful in cancelling out undesirable ripple components in the rectified signal.

4-51. Phase Detector

A pair of symmetrical, limited signals enter the detector section (WF-8). From these the detector derives a d-c signal which is proportional to the phase difference between the reference pulse and the midpoint of the two horizon intercepts. The phase sensitive rectifier consists of two SPDT polarized relays, or choppers, driven in phase opposition by the reference signal. These are designated K101 and K102 (WF9). The use of two choppers provides the advantages of full wave rectification, notably low ripple.

To understand the action of the synchronous rectifier, it is essential to know the relative phasing of the drive and horizon signals. Since the two choppers are driven 180° out of phase, the arm of one connects its capacitor to the source while the arm of the other connects its capacitor to the load. Switch-over takes place when the radial sector of the scanning beam crosses the vertical reference mark of the sensor and switching back occurs 180° later. Thus, when it is connected to the source each storage capacitor receives part of the sky pulse and part of the earth pulse. The capacitor is charged positively during the switched in portion of the earth pulse and negatively during the switched in portion of the sky pulse. If the sensor horizontal is parallel to the horizon, each capacitor is negatively charged an amount equal to the positive charge. Therefore, the net charge is zero. If the sensor tilts with respect to the horizon the amount that each capacitor charges positively is not equal to the amount it charges negatively. The net charge is, therefore, no longer zero. The net signal at the input of the d-c amplifier is thus positive for a positive tilt of the sensor (cw as viewed from the sensor along the scan axis) and negative for a tilt in the opposite direction. WF-9 and WF-10 indicate respectively the voltage of each chopper and the uncombined output.

4-52. D-C Amplifier

The output of the phase detector is combined and filtered in an R-C network at the input of the d-c amplifier. The signal at this point varies approximately 100 mv per degree of tilt and the average level is - 0.15 volts. The amplifier input is at high impedance to maintain a low ripple factor. With a gain of approximately three, the output of the amplifier is 286 mv per degree tilt of the sensor, reversing polarity at zero tilt. Part of the output is fed back to the emitter of the input stage. The balanced circuit configuration minimizes the output drift with temperature fluctuations.

4-53. SP-HL Detection Circuit

There are two conditions under which unwanted error signals are generated, namely, when the sun appears in the scan and when the horizon is lost. Signals produced under these conditions trigger a logic circuit which indicates by its output that the sun is present or the horizon is lost (hence the designation SP-HL circuit). This output can be used to disconnect the d-c error output from the vehicle guidance system. The effect of sun presence is shown graphically in the waveforms of Figure 4-24. The sun pulse introduces an unsymmetrical element into the signal train, and the horizon information derived from it is likely to be false. The presence of the sun's radiation is perceived at the detector. The sun radiation is hundreds of times greater than that of the earth. The stars and other bodies produce negligible signals. When a sun pulse occurs, the second stage of the pre-amplifier puts out a negative pulse with a peak amplitude of three to four volts. This pulse causes the Void Signal Circuit to produce an output. When a horizon is present in a normal scan a signal of 5 of 6 volts from the signal centering circuit suffices to keep the void circuit amplifier shut off. The absence of the signal when the horizon is lost has the same effect as a sun pulse -- it causes the void amplifier to conduct with a consequent output current of 4 ma into a load of 2000 ohms or less.

4-54. Phase Reference Signal Circuit

A phase reference signal is produced by the scanning system whenever it passes through its highest point with respect to the Sensor. The reference signal is generated in the scanning system. It consists of two equally spaced pulses, one positive and one negative, for each revolution of the scanning system. These pulses trigger the bistable multivibrator. The two-level detector section is in synchronism with the scan cycle. The output of the reference generator under various operating conditions is shown in Figure 4-24.

4-55. Power Supply

All the power required to operate the sensor is derived from the 110 volt, 400 cps line by a built-in power supply. Input to the supply is through the transformer. The primary of this transformer is tapped like an auto-transformer to provide low voltage a-c to operate the scanning motor. The transformer secondary output is full wave rectified to produce, -30, +30 and +16 volts d-c with respect to ground. The +30 and -30 volt outputs are fed to the Regulator. The +16 supplies the reference generator, and void signal circuits. Part of the transformer secondary voltage is rectified separately to produce unregulated power for use in the reference generator and the void signal output current amplifier.

4-56. Power Regulator and Super Regulator Circuits

The Regulator circuits convert the outputs of the power supply into regulated voltages for use in the sensor. Most of the voltages are regulated by cascaded zener diodes which maintain a substantially constant voltage across their terminals by an effect similar to break-down in a gas discharge regulator. The regulator also contains a symmetrical arrangement of transistors connected as emitter followers. Since the base potential of each transistor is fixed by zener action, the output voltage is accordingly regulated with reasonably low noise. This output is filtered and further regulated in the Super Regulator circuit to provide the highly regulated voltage required by the detector and pre-amplifier. This voltage is extremely stable and its noise content is essentially transistor noise. The zener diodes used in these circuits are 1/4 watt units which regulate within 5%.

4-57. TEST CONFIGURATION CAPSULES

4-58. TEST CONFIGURATION NO. 8 CAPSULE

The Automatic Stabilization Control System for Capsule No. 8 is identical to the Specification Compliance capsule with the exceptions noted in the following Paragraphs 4-59 through 4-62.

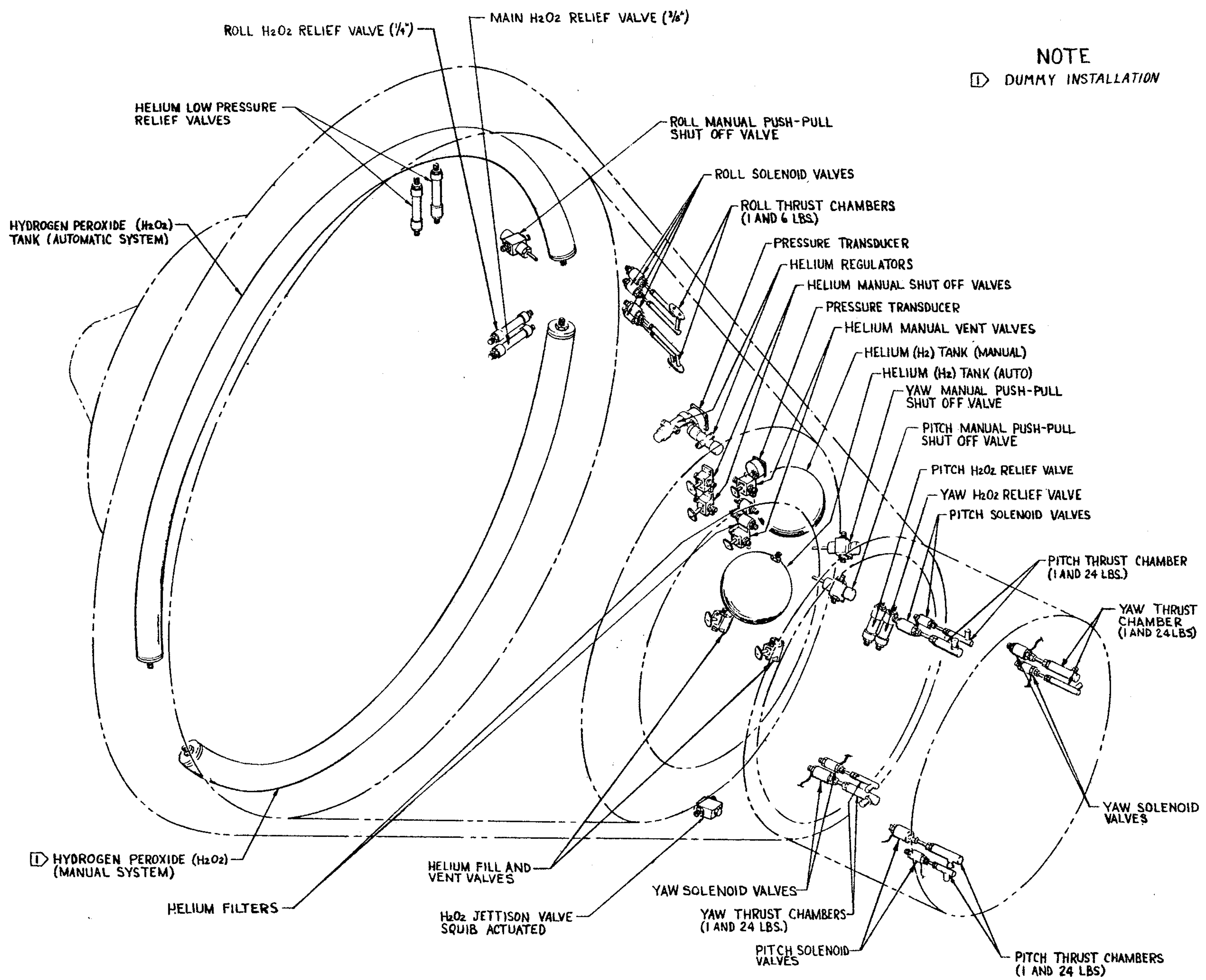


FIGURE 4-25 REACTION CONTROL SYSTEMS (CAPSULE 8)

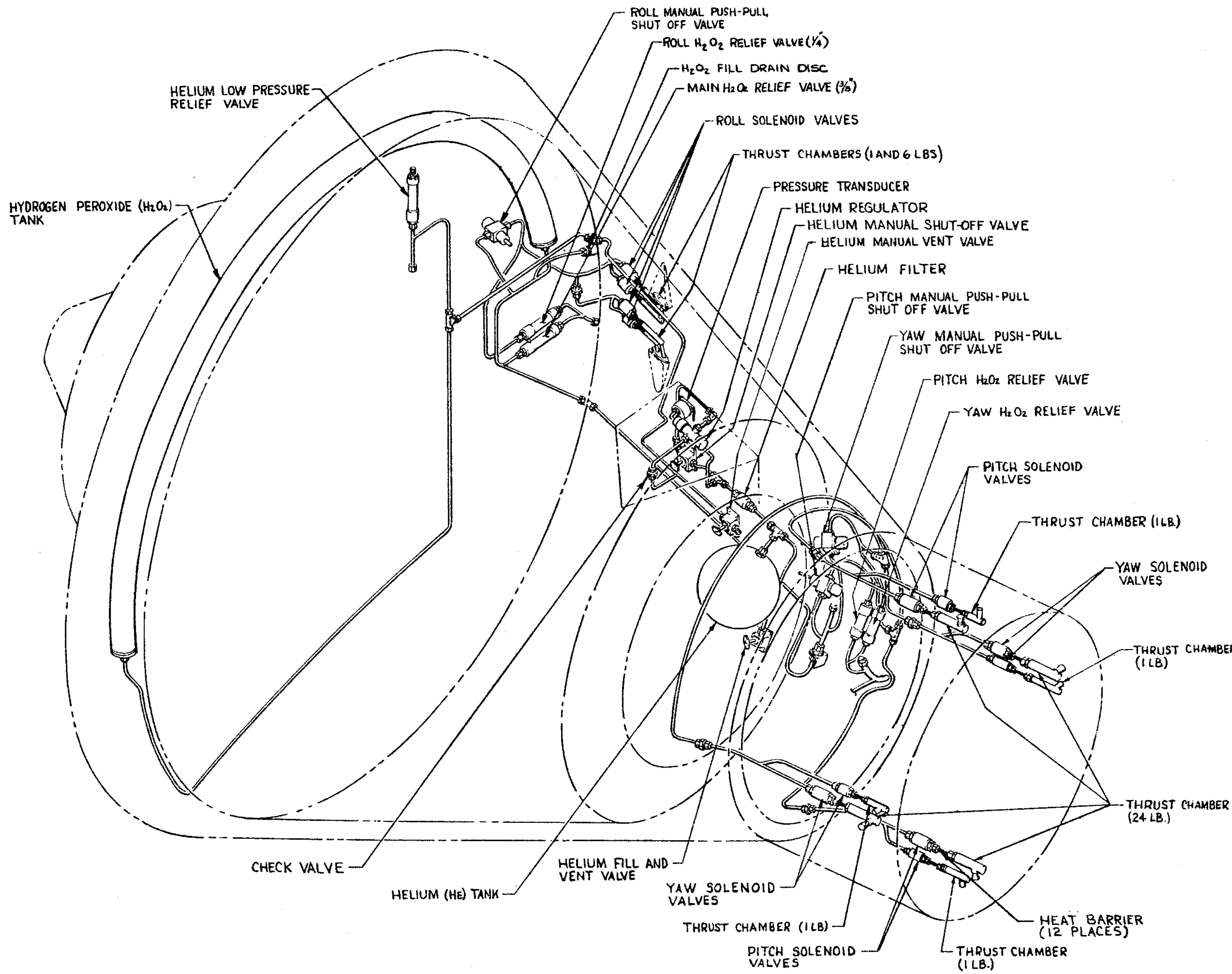


FIGURE 4-26 AUTOMATIC RCS INSTALLATION (CAPSULE 8)

CONFIDENTIAL

PM45-49C

4-59. Automatic Stabilization Control System

In general the discussion contained in Paragraphs 4-2 through 4-20 applies to Capsule 8. Two exceptions are the addition of a yaw data converter to permit telemetry monitoring of vertical roll and yaw torquer command signals, and the removal of ASCS power after the antenna fairing has been separated.

4-60. Rate Stabilization Control System

Capsule No. 8 is not equipped with a Rate Stabilization Control System, therefore Paragraphs 4-21 through 4-27 do not apply.

4-61. Reaction Control System

Capsule No. 8 is not equipped with a Manual RCS System with the exception of the fuel tank which has been installed and connected to the Automatic RCS System to provide additional fuel. All text contained in Paragraphs 4-28 through 4-35 pertaining to the automatic system applies with the exception of component location. For automatic system component location and tubing configuration, see Figure 4-25 and 4-26. Additional differences between Capsule No. 8 and Specification Compliance include helium regulator output pressure and thrust chamber composition, helium regulator output pressure for Capsule No. 8 is 460 psi. Capsule No. 8 thrust chambers do not contain the filter and screen shown in Figure 4-20.

4-62. Horizon Scanner

Same as Specification Compliance. Refer to Paragraphs 4-37 through 4-56.

4-63. TEST CONFIGURATION CAPSULE NO. 9

The Automatic Stabilization Control System for Capsule No. 9 is the same as the Specification Compliance capsule with the exceptions noted in the following Paragraphs 4-64 through 4-67.

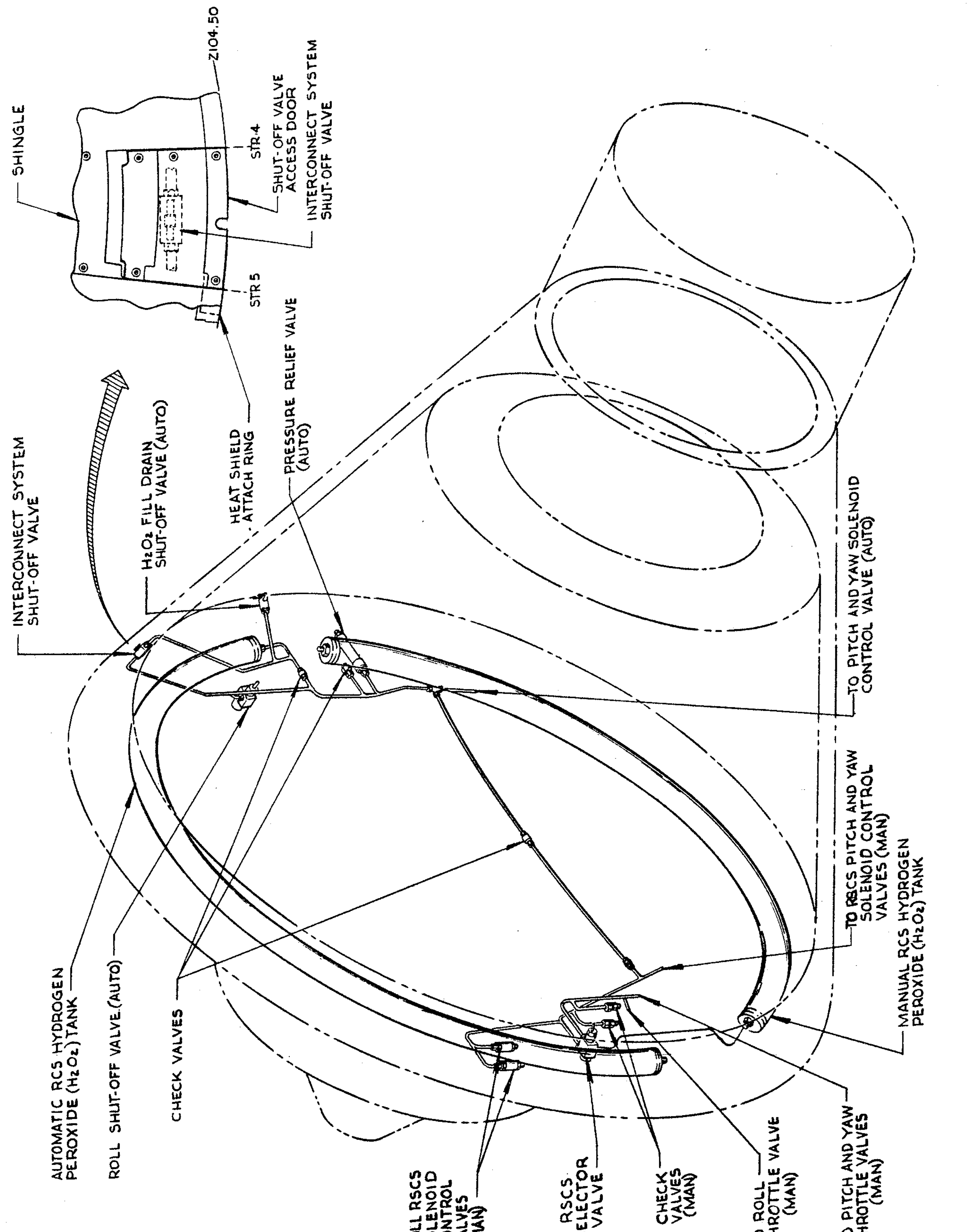


FIGURE 4-27 INTERCONNECTION OF AUTOMATIC AND MANUAL RCS FUEL SUPPLY (CAPSULE 9)

PM45-269

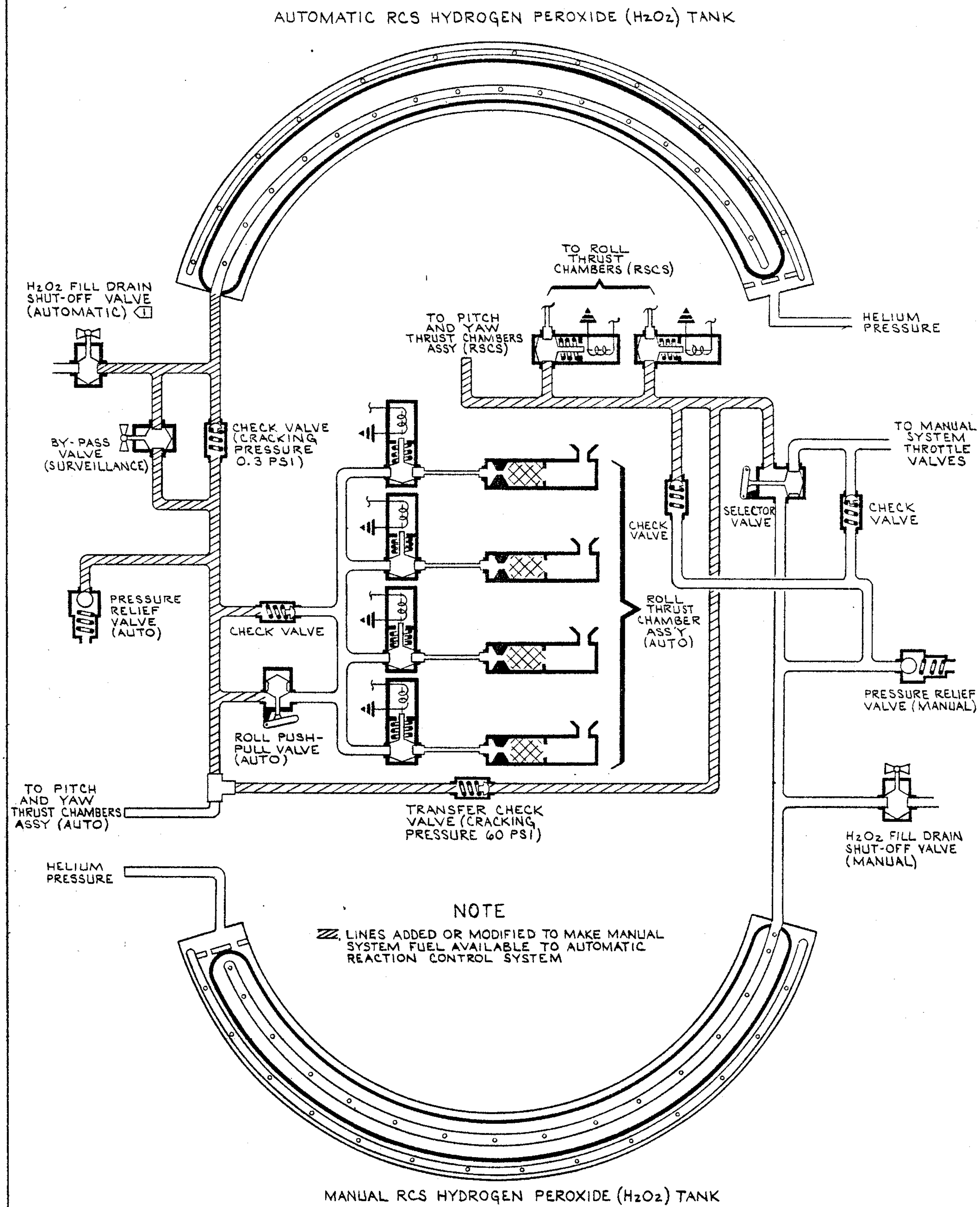


FIGURE 4-28 INTERCONNECTION OF AUTOMATIC AND MANUAL RCS FUEL SUPPLY SCHEMATIC (CAPSULE 9)

4-64. Automatic Stabilization Control System

In general, Capsule No. 9 ASCS system is the same as Specification Compliance Capsule. Some slight differences do exist in the area of normal sequencing due to the different missions involved. For a detailed description of ASCS normal sequencing, refer to Paragraph 4-5 through 4-9.

Normal sequencing described in the foregoing referenced paragraph is adequate for Capsule 9 with two exceptions. ASCS operation ceases at antenna fairing separation when the ASCS power is removed. Also a yaw data converter has been added to the system to permit telemetering the command signals generated by the Automatic Stabilization Control System. Refer to Paragraph 13-145.

4-65. Rate Stabilization Control System

Same as the Specification Compliance Capsule. Refer to Paragraphs 4-21 through 4-27.

4-66. Reaction Control System

The Reaction Control System on Capsule No. 9 is the same as the specification compliance capsule with two exceptions. The control stick is not installed and the Manual Reaction Control System hydrogen peroxide fuel tank is connected to the Automatic Reaction Control System to provide an additional fuel supply for the automatic control system. See Figures 4-27 and 4-28. Refer to paragraphs 4-28 through 4-35.

4-67. Horizon Scanner System

Same as specification compliance capsule. Refer to Paragraphs 4-36 through 4-56.

4-68. TEST CONFIGURATION CAPSULE NO. 13

The Automatic Stabilization Control Systems for Capsule 13 are identical to those discussed in Paragraphs 4-2 through 4-56 which apply to the Specification Compliance Capsule.

4-69. Automatic Stabilization Control System

Same as Specification Compliance. Refer to Paragraphs 4-2 through 4-20.

4-70. Reaction Control System

Same as Specification Compliance. Refer to Paragraphs 4-28 through 4-35.

4-71. Horizon Scanner System

Same as Specification Compliance. Refer to Paragraphs 4-37 through 4-56.

4-72. TEST CONFIGURATION CAPSULES NO. 10 AND 16

The Automatic Stabilization Control System in Capsules No. 10 and No. 16 is the same as the Specification Compliance Capsule. Refer to Paragraphs 4-1 through 4-56.

4-73. Automatic Stabilization Control System

Same as Specification Compliance. Refer to Paragraphs 4-2 through 4-20.

4-74. Reaction Control System

Same as Specification Compliance. Refer to Paragraphs 4-28 through 4-35.

4-75. Horizon Scanner System

Same as Specification Compliance. Refer to Paragraphs 4-37 through 4-56.

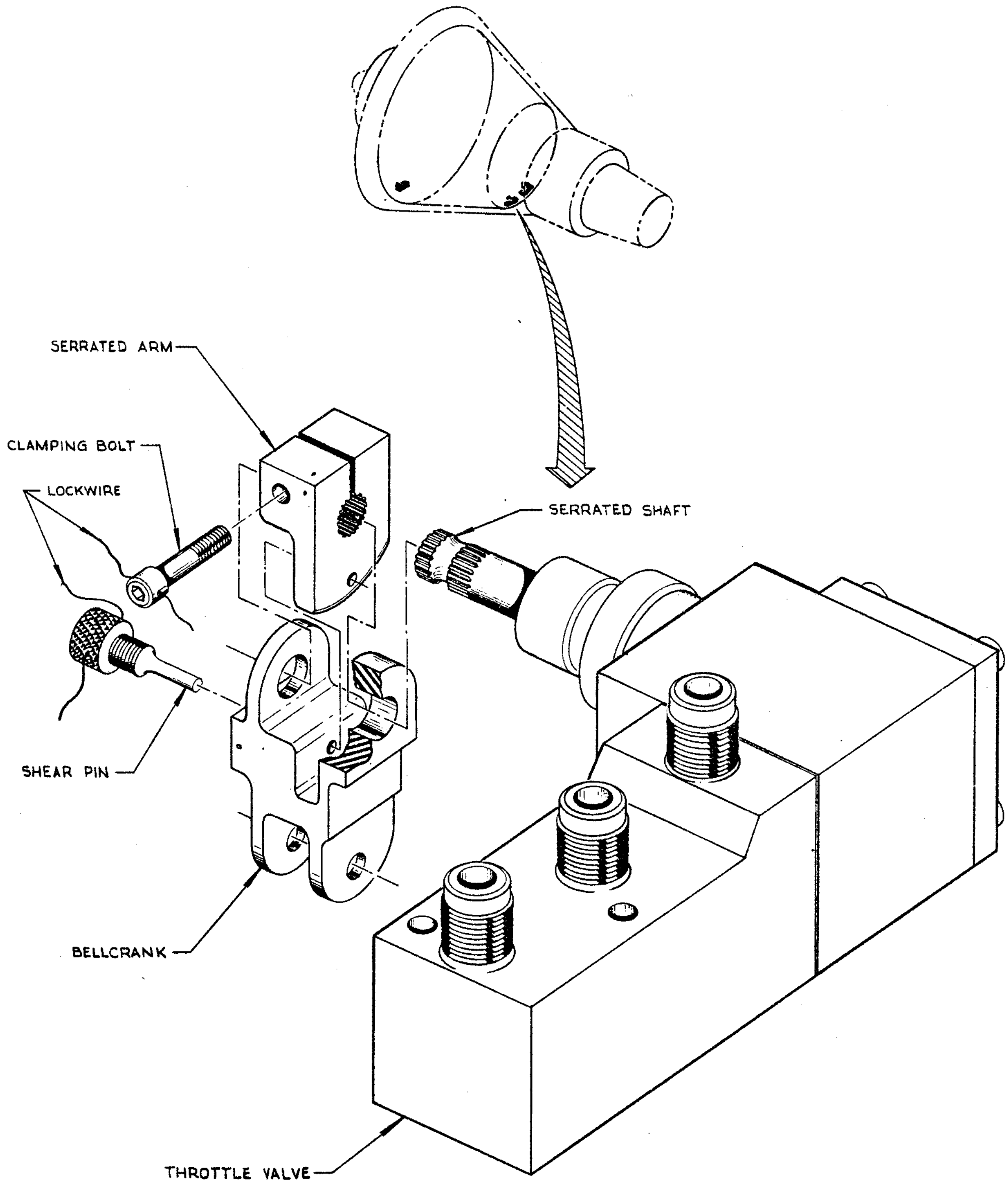
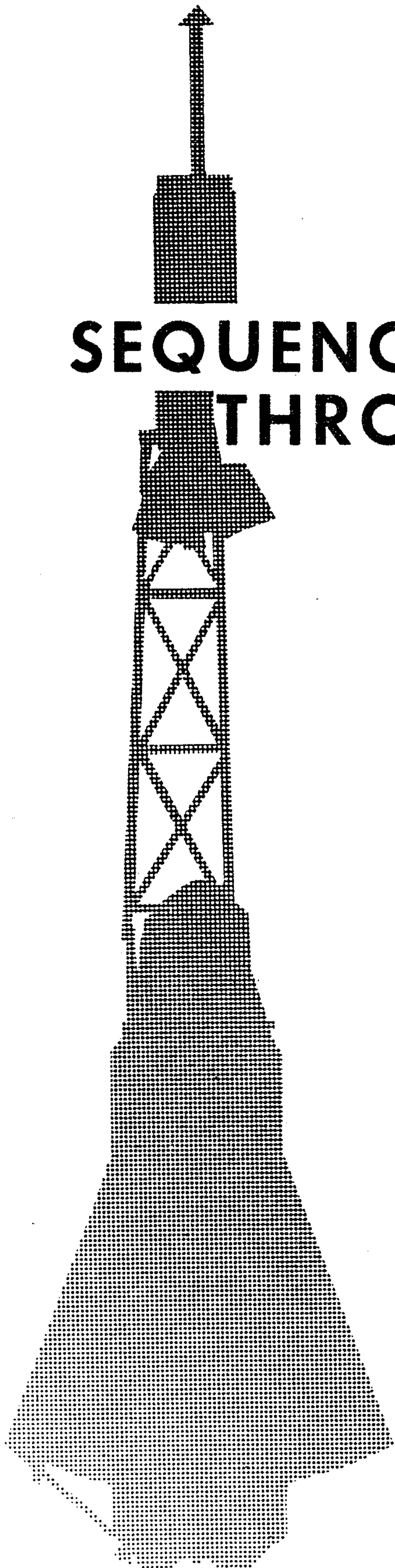


FIGURE 4-29 MANUAL RCS THROTTLE VALVE AND BELLCRANK

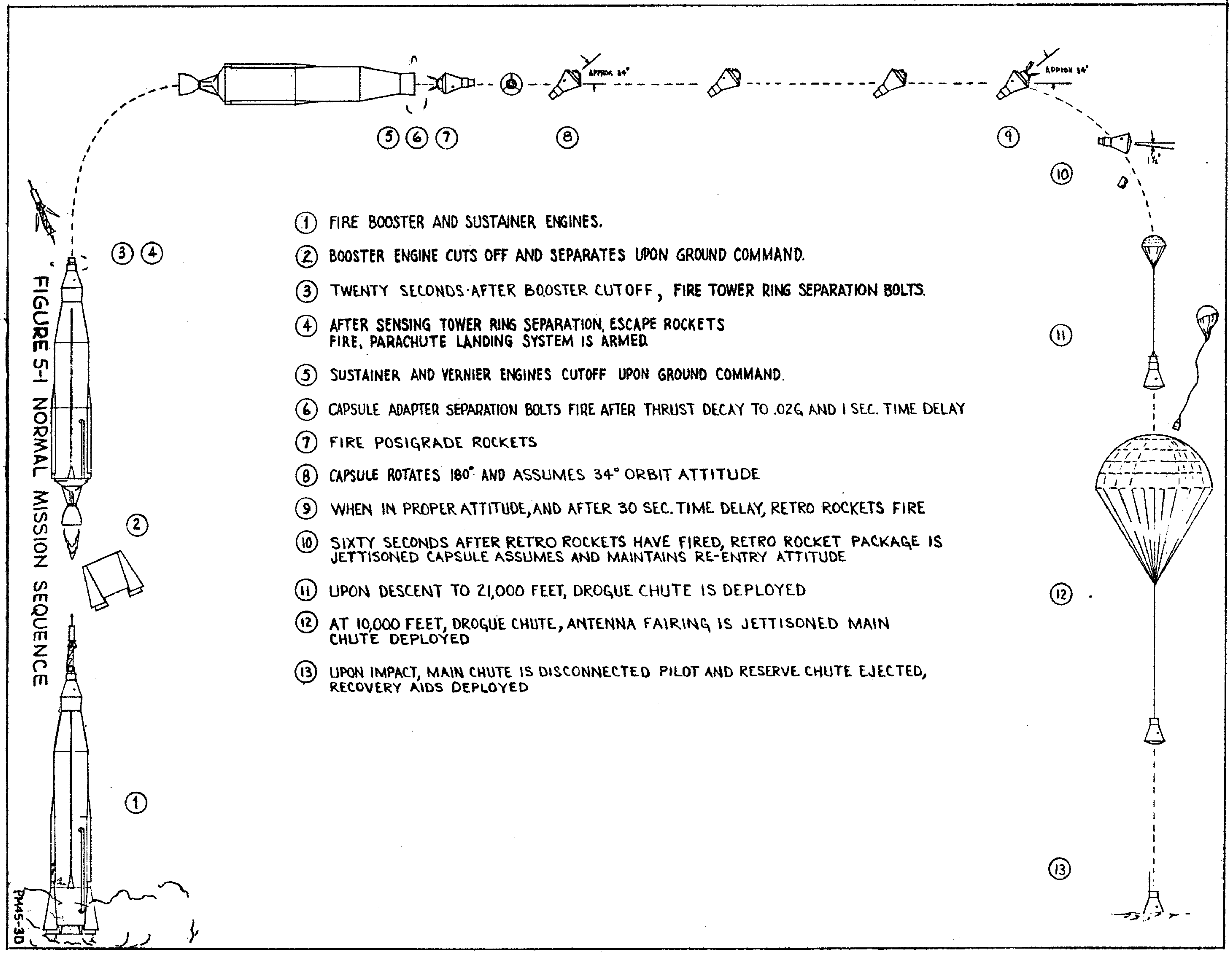
PM45-270

SECTION V



SEQUENCE SYSTEM, LAUNCH THROUGH RETROGRADE OR ABORT

TABLE OF CONTENTS



1. FIRE BOOSTER AND SUSTAINER ENGINES.
2. BOOSTER ENGINE CUTS OFF AND SEPARATES UPON GROUND COMMAND.
3. TWENTY SECONDS AFTER BOOSTER CUTOFF, FIRE TOWER RING SEPARATION BOLTS.
4. AFTER SENSING TOWER RING SEPARATION, ESCAPE ROCKETS FIRE, PARACHUTE LANDING SYSTEM IS ARMED.
5. SUSTAINER AND VERNIER ENGINES CUTOFF UPON GROUND COMMAND.
6. CAPSULE ADAPTER SEPARATION BOLTS FIRE AFTER THRUST DECAY TO .02G AND 1 SEC. TIME DELAY
7. FIRE POSIGRADE ROCKETS
8. CAPSULE ROTATES 180° AND ASSUMES 34° ORBIT ATTITUDE
9. WHEN IN PROPER ATTITUDE, AND AFTER 30 SEC. TIME DELAY, RETRO ROCKETS FIRE
10. SIXTY SECONDS AFTER RETRO ROCKETS HAVE FIRED, RETRO ROCKET PACKAGE IS JETTISONED CAPSULE ASSUMES AND MAINTAINS RE-ENTRY ATTITUDE
11. UPON DESCENT TO 21,000 FEET, DROGUE CHUTE IS DEPLOYED
12. AT 10,000 FEET, DROGUE CHUTE, ANTENNA FAIRING IS JETTISONED MAIN CHUTE DEPLOYED
13. UPON IMPACT, MAIN CHUTE IS DISCONNECTED PILOT AND RESERVE CHUTE EJECTED, RECOVERY AIDS DEPLOYED

FIGURE 5-1 NORMAL MISSION SEQUENCE

V. SEQUENCE SYSTEM, LAUNCH THROUGH RETROGRADE OR ABORT

5-1. NORMAL MISSION SEQUENCE

5-2. LAUNCH THROUGH STAGING

5-3. DESCRIPTION

The launch through staging sequence establishes basic references at time of launch and then remains inactive until staging. At staging, the missile's booster engine separates, resulting in the escape tower bolts being fired after a twenty seconds time delay. The escape rockets are fired immediately after tower bolt detonation and subsequently the landing system becomes armed.

5-4. OPERATION

The sequence system is initiated by two 28 V d-c signals from the missile which occur at 2 inches after liftoff (See Figure 5-2). This is known as time zero reference and energizes a Time Zero latching relay in the No. 3 Launch and Orbit relay box located within the capsule. An Astronaut controlled back-up switch is provided in the event the 28 V signals from the missile do not reach the capsule. These same signals are also sent to the Maximum Altitude Sensor and the Satellite Clock. The signal to the Maximum Altitude Sensor results in establishing the function of time lift-off versus the time an abort may occur. At approximately 135 seconds missile staging will occur whereby the mechanical separation of the booster engine will cause the loss of capsule power to the Booster Engine Separation Sensor relay. Through this de-energized relay, power will be applied to the Tower Jettison 20 Second Time Delay relay. After the 20 second time delay, power will be applied to energize the Tower Separation Bolts Power relay and the Tower Jettison Warning Light 2 Second Time Delay relay. The Tower Separation Bolts Power relay is armed by both the Main and Isolated d-c squib bus through the SQUIB ARM switch. When energized, the Isolated squib

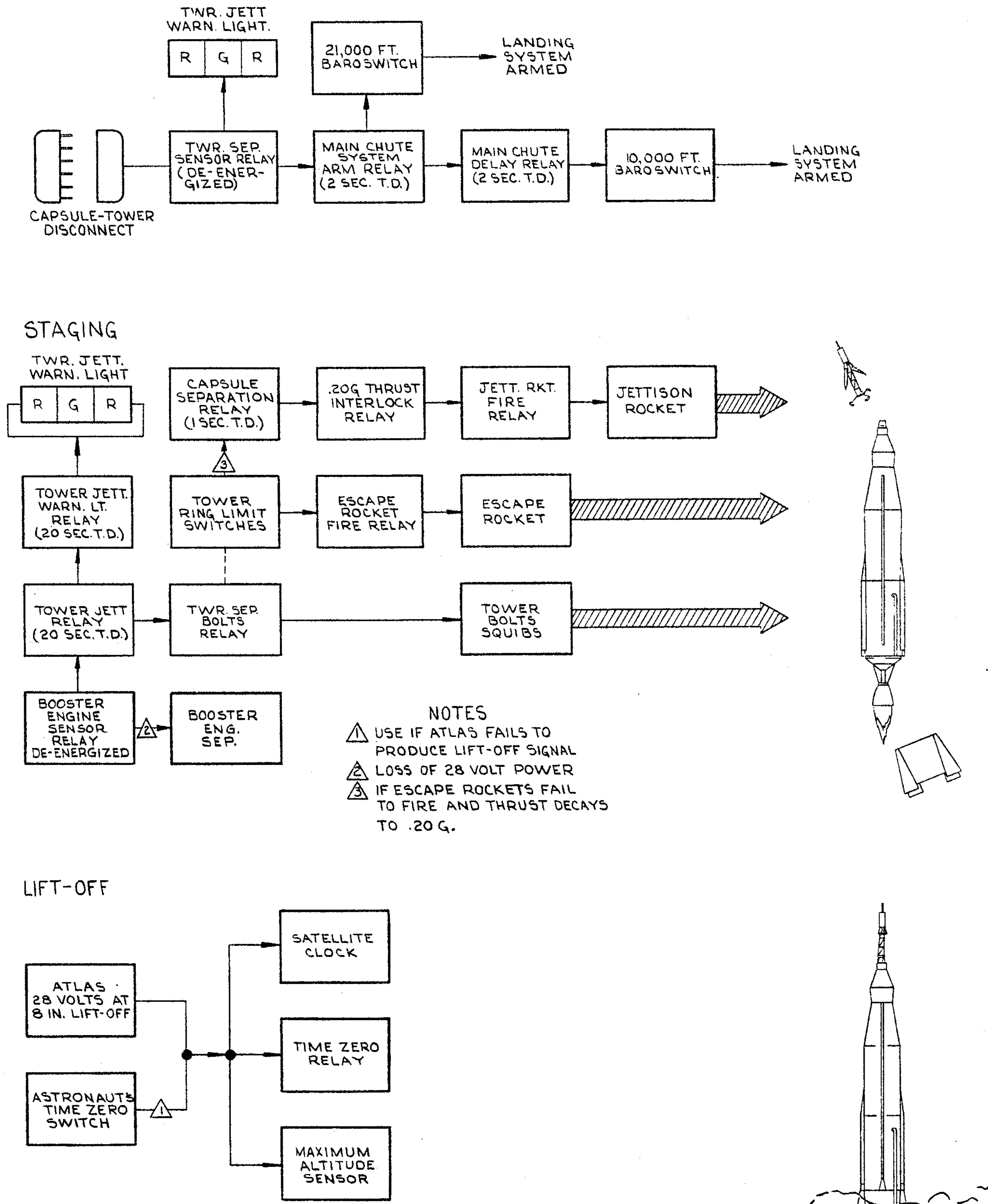


FIGURE 5-2 LAUNCH THROUGH STAGING
(BLOCK DIAGRAM)

PM45-265

bus power fires two of the five squibs (2 bolts) and main squib bus power fires three of the five squibs (3 bolts). As the three segmented Tower Clamp ring separates, the three Tower Clamp ring limit switches return to the normal position and allow Isolated and Main squib bus power through their contacts. The Isolated squib bus power energizes both the Emergency Escape Rocket Fire relay and the Emergency Jettison Rocket Fire relay, while the Main squib bus power energizes both the Escape Rocket Fire relay and the Jettison Rocket Fire relay. As the contacts of the Emergency Jettison and Jettison Rocket Fire relays are connected in parallel, either relay will fire both squibs of the jettison rocket from the two different power sources. The Emergency Escape and Escape Rocket Fire relays are connected in the identical same manner and will fire both squibs of the escape rocket from both power sources. Power to energize the Emergency Jettison and Jettison Rocket Fire relay is routed through the Capsule Separation 1 Second Time Delay relay. As the result of the 1 second delay the Tower Clamp Ring separates, the Escape Rockets fire and separates the tower from the capsule with the Jettison Rockets unfired. When this is accomplished, two electrical disconnects between the tower and capsule are separated and remove power from the three Tower Separation Sensor relays. Through the de-energized No. 1 Tower Separation Sensor relay the green JETT TOWER light on the telelight panel illuminates. When the tower and the capsule separate, the No. 1 and No. 2 Tower Separation Relays are de-energized, allowing power to energize the No. 1 and No. 2 Main Chute System Arm 2 Second Time Delay Relays. After 2 seconds delay, the Main Chute Relays arm the 21,000 foot baroswitches and the Main Chute Delay 2 Second Time Delay relays. After two seconds the 10,000 foot baroswitches are armed. The power circuit will hold at these two points until the capsule descends down through the 21,000 foot range, at which time the landing sequence is initiated. Refer to Section IX of this manual.

5-5. SECOND STAGING

5-6. DESCRIPTION

Second staging is initiated by sustainer engine cutoff at which time the capsule adapter bolts are fired providing acceleration has decayed to .20g. The three posigrade rockets and the four explosive electrical disconnects are fired immediately after the bolts are detonated and result in capsule separation. Capsule separation is sensed and initiates five seconds of rate damping which is followed by orbit orientation in which the capsule rotates 180° degrees and settles into a 34° orbit attitude.

5-7. OPERATION

At approximately 285 seconds after launch, second staging will occur (See Figure 5-3). At this time a 28 volt d-c signal from the missile will energize the Sustainer Engine Cutoff Relay. When the thrust drops below .20g, the .20g switch in the Thrust Cutoff Sensor closes. Power is then supplied through the Capsule Separation 1 Second Time Delay and Sustainer Engine Cutoff Relays after the 1 Second Time delay to energize the Capsule Separation Bolts Power and the Capsule Separation Warning 2 Second Time Delay relays. Through the energized contacts, power from the Main and Isolated bus fire the Capsule Separation Bolts. Also Main bus power is supplied through the Warning Light Time Delay relay to illuminate the Red Capsule Separation Sequence Light on the Left Hand Console. When the Tri-segmented Capsule-to-Adapter clamp ring separates it allows the Capsule Adapter Ring Limit Switch to close supplying power to energize the Posigrade Rocket Fire, Emergency Posigrade Rocket Fire and the Capsule Adapter Disconnect Squib Fire relays. The Main and Isolated busses supply power through the energized contacts of these relays to fire the Posigrade Rockets and the four Capsule Adapter Explosive Disconnects. The Posigrade Rockets create sufficient thrust to separate the capsule from the adapter. This allows the three Capsule Separation Limit switches which are attached to the retrograde straps to close. Power from the Isolated squib bus flows through the closed contacts and activates the #1 Capsule Separation Sensor relay which extinguishes the Red Capsule Separation Warning Light and illuminates the Green Light. Power also flows from the Capsule Separation Sensor relay to the 5 Second Time Delay Damping Signal relay. Activation of the Damping Signal relay actuates the orbit orientation relay bringing the capsule to a 34° (blunt end up) orbit attitude.

5-8. RE-ENTRY

5-9. DESCRIPTION

In order for the capsule to impact at a designated area, the re-entry sequence must be initiated approximately 3000 nautical miles up range of the touchdown point. The method of initiating normal re-entry sequence is by the closing of the Retrograde Firing Signal switch within the Satellite Clock. The switch may be activated by the run-out of time pre-set into the clock prior to launch for a calculated re-entry time. Timing starts at booster lift-off. The time may also be pre-set by the Astronaut or by Ground Command when necessary. The sequence may be started directly by using Ground Command transmitters and the Capsule Command Receivers. The final method is for the Astronaut to manually start the sequence by pressing the Retro Sequence button. The last two methods by-pass the satellite clock. A brief resume of the sequence starts with the closing of the Retrograde Firing Signal switch, which energizes the Retro Sequence Fire 30 Second Time Delay relay. After the capsule has attained the proper attitude and the time delay has run out, the three Retro Rockets will fire 5 seconds apart. When the Retro Rockets fire and the Auto Retro Jettison switch is in the "ARM" position the Retro Rocket Assembly Jettison 60 Second Time Delay Relay is energized and at the run-out of the 60 second time delay the retro package is

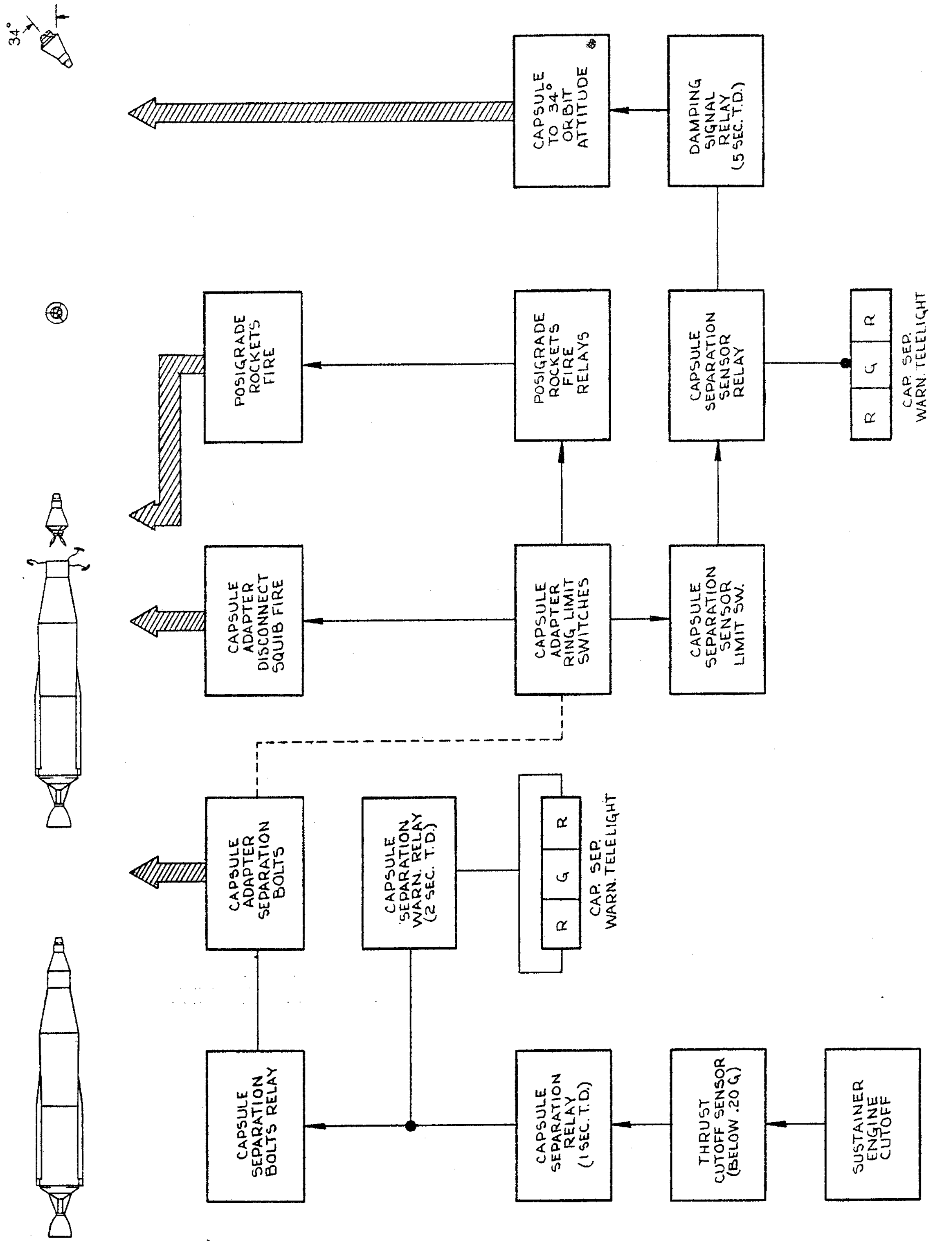


FIGURE 5-3 SECOND STAGING (BLOCK DIAGRAM)

PM45-266

jettisoned. The retro package separation is sensed and results in the separation of the three retro package electrical umbilicals.

5-10. OPERATION (See Figure 5-4)

The satellite clock Retro Fire switch is armed by Main Squib bus power through the Capsule Separation relay (See Figure 5-4). With the Retro Delay switch in the "NORM" position and the Retro Fire switch closed by any of the three previously mentioned methods, the Retro Rocket Sequence Fire 30 Second Time Delay relay is energized. At the same time the Retro Sequence Indicator Relay is activated illuminating the Green Retro Sequence Indicator light. With the Retro Delay switch in the "INST" position power is supplied directly to the contact of the Attitude Permission Relay No. 1 by-passing the 30 second delay. The Astronaut may manually start the Retro sequence by pressing the Retro Sequence switch on the left hand console which will energize the Emergency Retro Sequence Relay and allow the normal sequence to be followed. The Retro Interlock switch in the ASCS Calibrator closes allowing power to flow through the Emergency Retro Fire No. 1 Relay and energize the No. 1 and No. 2 Attitude Permission Relays when the capsule is in the proper position for Retro Rocket firing. The Red Retro Attitude telelight is switched on when the Retro Rocket Sequence Fire Relay, 30 second time delay is depleted and the capsule has not attained the proper re-entry attitude.

Normally, the Attitude Permission Relay extinguishes the Red Retro Attitude telelight, illuminating the Green light and energizing the Retro Signal Latch and the Retro Rocket Fire Relays. Power from the Isolated Squib bus is now routed through the Retro Rocket Fire Relays to the Retro Rockets in turn firing first the Left (No. 1) Rocket, after a 5 second time delay the Bottom (No. 2) Rocket and 5 seconds later the Right (No. 3) Rocket. Through the Retro Signal Latch Relay, a circuit will be completed to energize the Retro Fire Signal

Disengage 23 Second Time Delay Relay. The power to the coil of the Retro Fire Signal Disengage Relay allows the circuit to be completed to the ASCS Calibrator resulting in hi-torque RCS operation. This high-torque operation will last for 23 seconds, which is 3 seconds more than the duration of total retro rocket firing. The high-torque mode holds the capsule in the 34° attitude while the rockets are firing. At the end of 23 seconds, the Retro Fire Signal Disengage 23 Second Time Delay relay will energize removing power from the Retro Fire Signal relay and thus removing the high-torque signal. With the Attitude switch in the "AUTO" position the Astronaut may press the Retro Fire switch energizing the No. 1 Emergency Retro Fire relay allowing Isolated bus power to energize the No. 2 Emergency Retro relay powering contacts on the No. 2 Attitude Permission Relay firing the Retro Rockets when the capsule assumes the proper attitude. With the Retro Attitude switch in the "BY-PASS" position, and pressing the Retro Fire switch which energizes the Attitude Permission By-Pass relay, the Retro Rockets will be fired regardless of the attitude of the capsule. When the Retro Signal Latch relay is energized, Main Squib bus power is supplied to energize the Retro Rocket Assembly Jettison 60 Second Time Delay relay and the Retro Fire Warning Light 20 Second Time Delay relay. After the 20 second time delay has run out the Red Fire Retro Telelight is illuminated. When velocity decreases to 240 ft./sec. the velocity sensor supplies pre-impact, Main bus power to energize the Retro Rocket Fired Relay, activating the relay removing power from the Red Fire Retro telelight and illuminating the Green light. With the Automatic Retro Jettison switch in the "ARM" position, at the end of the 60 second time delay the Retro Rocket Assembly Jettison 60 Second Time Delay relay allows power to energize the Retro Rocket Assembly Jettison relay and the Jettison Retro Warning Light 2 Second Time Delay relay. As the 2 second time delay is expired the Red Jettison Retro telelight is illuminated. The Retro Rocket Assembly Jettison relay directs Main and Isolated bus power to the two squibs of the Retro Rocket Assembly Jettison Bolt. The bolt will fracture and the package will drop free of the capsule, being assisted by a coil spring installed between the heat shield and Retro package Assembly. The dropping of the retro package assembly from the capsule will allow the three Retro Rocket Assembly Separation Sensors (single pole limit switches) to return to their normal position energizing the Retro Rocket Assembly Separation relay. This will allow the Retro Rocket Assembly Umbilical Separation relay to energize, firing the six squibs of the three Retro Rocket package umbilicals and jettison the electrical umbilical plugs milliseconds after dropping of the retro package. When the Retro Rocket Assembly Umbilical Separation Relay is activated, it removes power from the Red Jettison Retro telelight and illuminates the Green light. When the Retro Rocket Assembly Separation relay is energized, it activates the Accelerometer Arm 5 Second Time Delay relay. At the end of the 5 second time delay, the relay functions supplying a ground for Main bus power which operates the .05g relays. The energizing of the No. 1 and No. 2 .05g Retro Sequence Drop, .05g Jettison Assembly Sequence Drop, and .05g Retro Telelight Power Drop relays removes power from the various relays and switches involved in the Retro Sequence as well as extinguishing the Retro telelights.

5-11. ESCAPE SYSTEM

5-12. GENERAL DESCRIPTION

The escape system primarily consists of a tower assembly designed to provide a safe means of abort between prelaunch and staging. By utilizing the posigrade rocket system, escapes may still be initiated after booster staging and throughout sustainer operation until orbit. The tower assembly consists of a 10 foot, tubular steel structure with a 4 foot escape rocket mounted to its tapered end. A segmented clamp ring with 3 explosive bolts secures the base of the tower to the recovery compartment upper flange. Attached to the escape rocket nozzle adapter plate is a jettison rocket which is used to jettison the tower assembly after the escape rocket has been fired for an abort; however, under normal launch conditions the escape rockets are fired to accomplish tower separation at time of booster engine separation.

5-13. ESCAPE BEFORE LIFTOFF BEFORE UMBILICAL DISCONNECT

Only one ground controlled signal will energize the Mayday relays. This signal is a direct hardline from the blockhouse abort switch through the missile to the capsule Mayday relays. In the event that the capsule must be aborted on the launch pad and the missile is unable to transmit the hardline abort signal, there is one other method which may be selected. Umbilical pins 44 and 45 are abort wired and transmit 28 V power from the blockhouse to the capsule's Ground Command Abort Signal Latching relay, energizing and locking in the relay. Through this energized relay capsule 28 V Squib Arm Bus power is transmitted to the pole of the Ground Test Umbilical relay; however, power will not continue through this relay until the relay is de-energized. The only way the relay may be de-energized is by ejecting the umbilical. Therefore, if this abort method is required to be used it would be necessary for the blockhouse conductor to first select the Abort switch (power to pins 44 and 45) and then milliseconds thereafter eject the umbilical.

5-14. ESCAPE BEFORE LIFTOFF AFTER UMBILICAL DISCONNECT

During countdown there will be approximately 50 to 90 seconds between time of capsule umbilical eject and time zero, which is two inches liftoff. During this period, the three available methods of abort are: (1) The blockhouse to missile hardline abort signal as explained in the previous paragraph; (2) Ground command receiver abort signal; (3) Astronaut's Abort handle. These three methods all result in energizing the Mayday relays.

5-15. ESCAPE AFTER LIFTOFF BEFORE TOWER SEPARATION

After liftoff, (Time Zero), there are three methods by which an abort may be initiated. They are: (1) Ground command receiver abort signal and (2) Astronaut Abort handle, both of which were possible methods in the previous paragraph, (3) The Booster Catastrophic Failure Detection system. This third method has been non-effective in the two previous paragraphs due to the Time Zero relay being de-energized. However, the Time Zero relay is energized two inches after liftoff and completes a circuit to the Mayday relays if the Catastrophic Failure Detection relay is de-energized by loss of power from the missile.

5-16. Operation

When the Mayday relays are energized, the abort sequence (See Figures 5-5 and 5-6) will occur as follows: The ABORT light on the left hand console will illuminate, the Capsule Separation Bolts Power relay is energized, the Capsule Separation Warning Light Time Delay relay is energized, and the Tower Jettison 20 Second Time Delay Relay is energized. After 20 seconds have elapsed the Abort Relay in the Maximum Altitude Sensor is energized. The Maximum Altitude Sensor computes the time delay required for the capsule to reach a safe dynamic pressure before jettisoning the escape tower. The capsule separation bolts squibs will be fired, releasing the capsule-adapter clamp ring and allowing the three limit switches to return to their normal positions energizing the Emergency Escape Rocket Fire relay, the Escape Rocket Fire relay and the Capsule Adapter Disconnect Squib Fire relay, firing the escape rocket and the four capsule adapter explosive disconnect squibs. The escape rocket's 56,000 pounds of thrust will separate the capsule from the missile and carry it away from the sustainer and at a small angle. The capsule separation sensor limit switches also energize the Capsule Separation Sensor relays, which turns on the Green capsule Separation

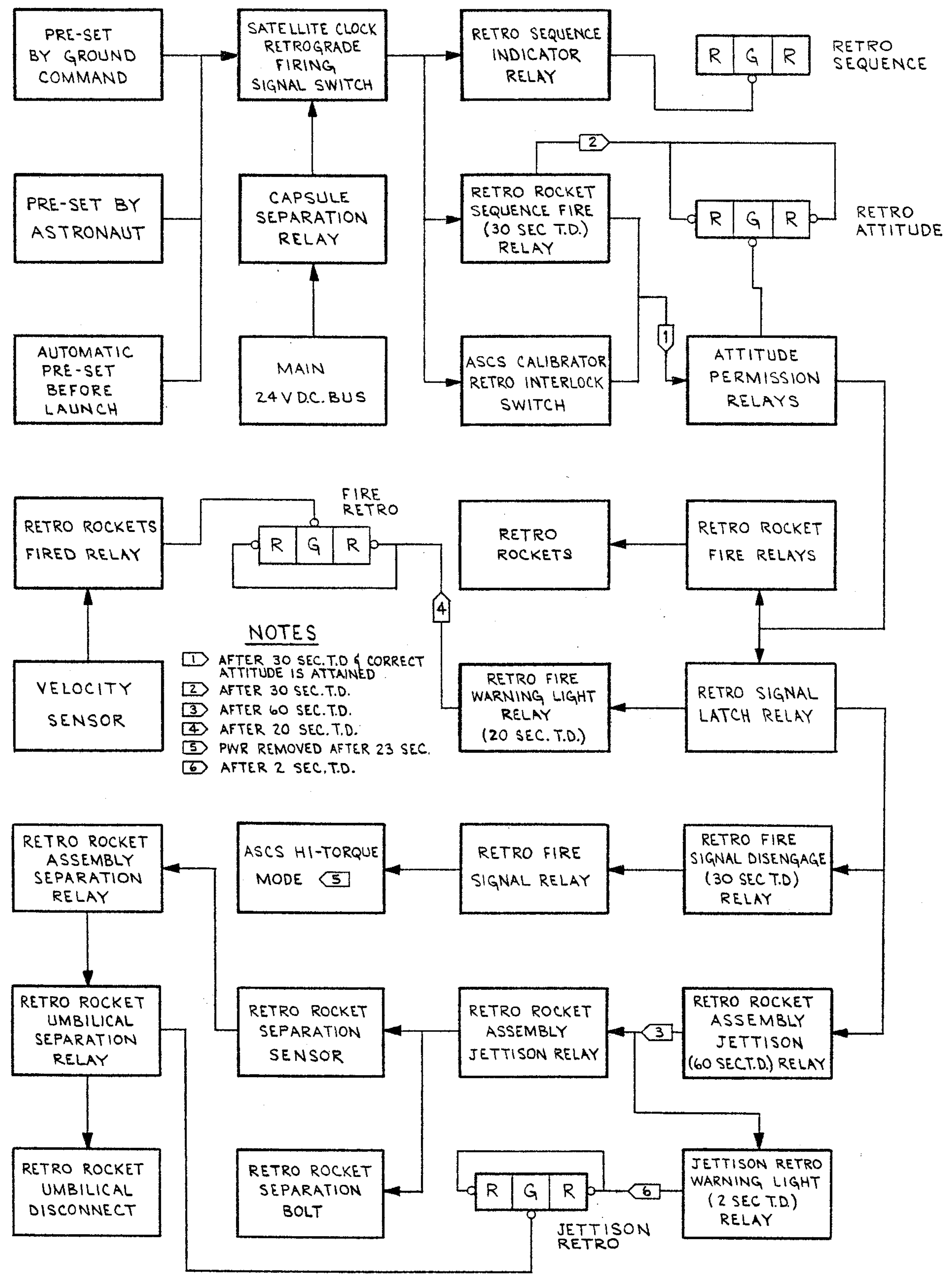
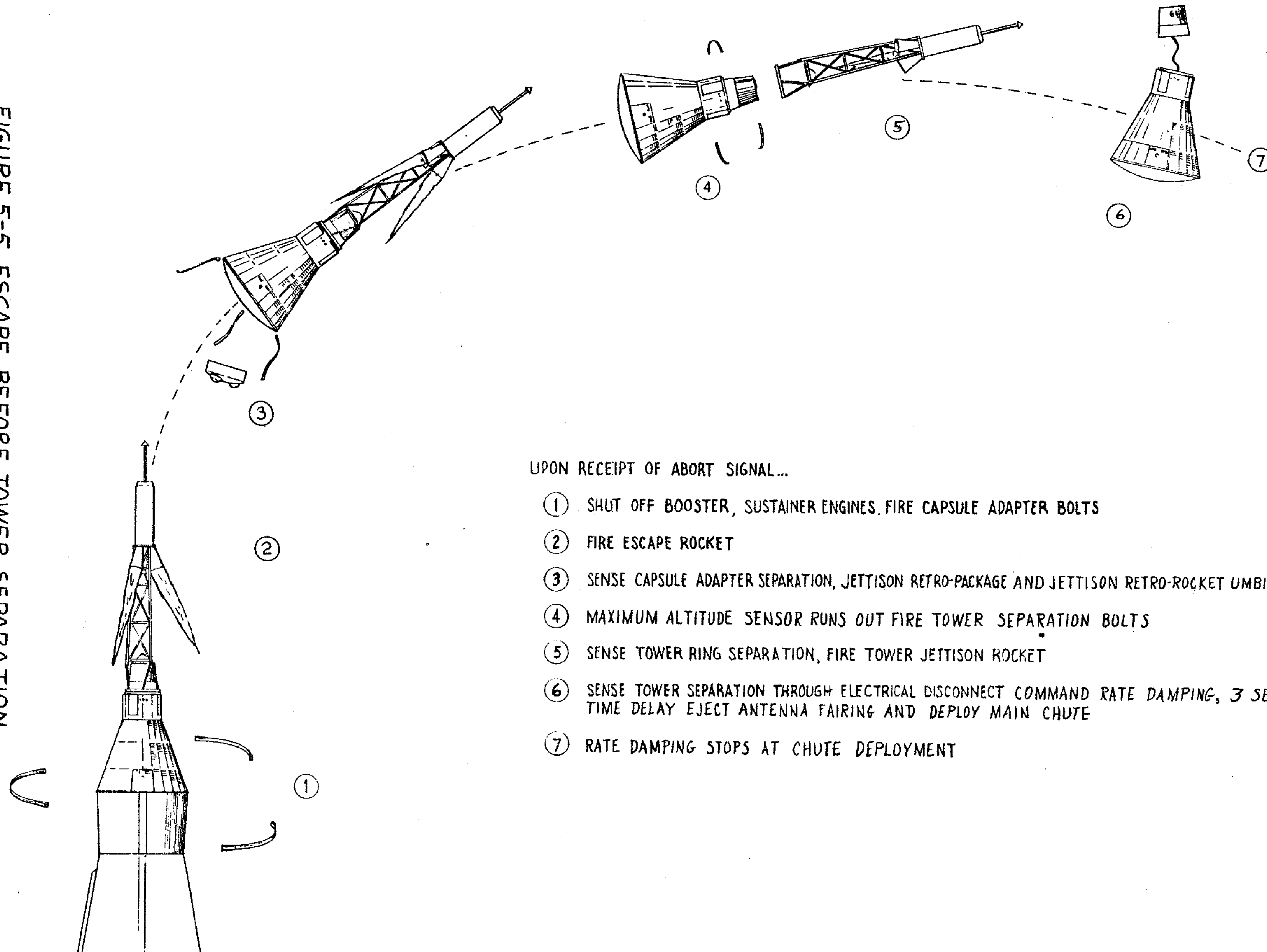


FIGURE 5-4 NORMAL RE-ENTRY SEQUENCE

PM45-235A



UPON RECEIPT OF ABORT SIGNAL...

1. SHUT OFF BOOSTER, SUSTAINER ENGINES, FIRE CAPSULE ADAPTER BOLTS
2. FIRE ESCAPE ROCKET
3. SENSE CAPSULE ADAPTER SEPARATION, JETTISON RETRO-PACKAGE AND JETTISON RETRO-ROCKET UMBILICALS
4. MAXIMUM ALTITUDE SENSOR RUNS OUT FIRE TOWER SEPARATION BOLTS
5. SENSE TOWER RING SEPARATION, FIRE TOWER JETTISON ROCKET
6. SENSE TOWER SEPARATION THROUGH ELECTRICAL DISCONNECT COMMAND RATE DAMPING, 3 SEC. TIME DELAY EJECT ANTENNA FAIRING AND DEPLOY MAIN CHUTE
7. RATE DAMPING STOPS AT CHUTE DEPLOYMENT

FIGURE 5-5 ESCAPE BEFORE TOWER SEPARATION

PM45-5B

telelight, and also energizes the Tower Separation Abort Interlock Latching relay. The abort interlock relay energizes the Retro Rocket Assembly Jettison relay through the "ARM" position of the Astronaut's Auto Retro switch and fires the two squibs of the retro rocket assembly jettison bolt. The bolt will fracture and the package will drop free of the capsule, being assisted by a coil spring installed between the heat shield and retro package assembly for this purpose. When the capsule reaches a maximum altitude, contacts in the MAX ALT SENSOR will close and energize the Tower Separation Bolts Power relay firing the bolts. As the three tower bolts are fractured, the segmented tower clamp ring separates allowing the three tower ring limit switches to return to their normal position energizing the Emergency Jettison and Jettison Rocket Fire relays. Through these relays and their parallel contacts Main and Isolated bus power will fire the two squibs of the jettison rocket. The tower will be jettisoned clear of the capsule resulting in separating the two tower to capsule electrical disconnects. The separation of either disconnect will de-energize the Tower Separation Sensor relays energizing the Abort Rate Damping relay. This relay will send a signal to the ASCS commanding rate damping until time of main chute deployment. De-energizing the Tower Separation relays will also start the two 2 second timers in the recovery sequence which will arm the 21,000 foot and 10,000 foot baroswitches after 2 seconds.

5-17. ESCAPE AFTER TOWER SEPARATION

The methods of initiating an abort after staging are identical to the methods named for the escape after liftoff and are: (1) Ground command receiver abort signal; (2) Astronaut Abort handle; (3) Booster Catastrophic Failure Detection system. Any of the three methods will energize the Mayday relays. The sequence which occurs by the energizing of these relays is described in the

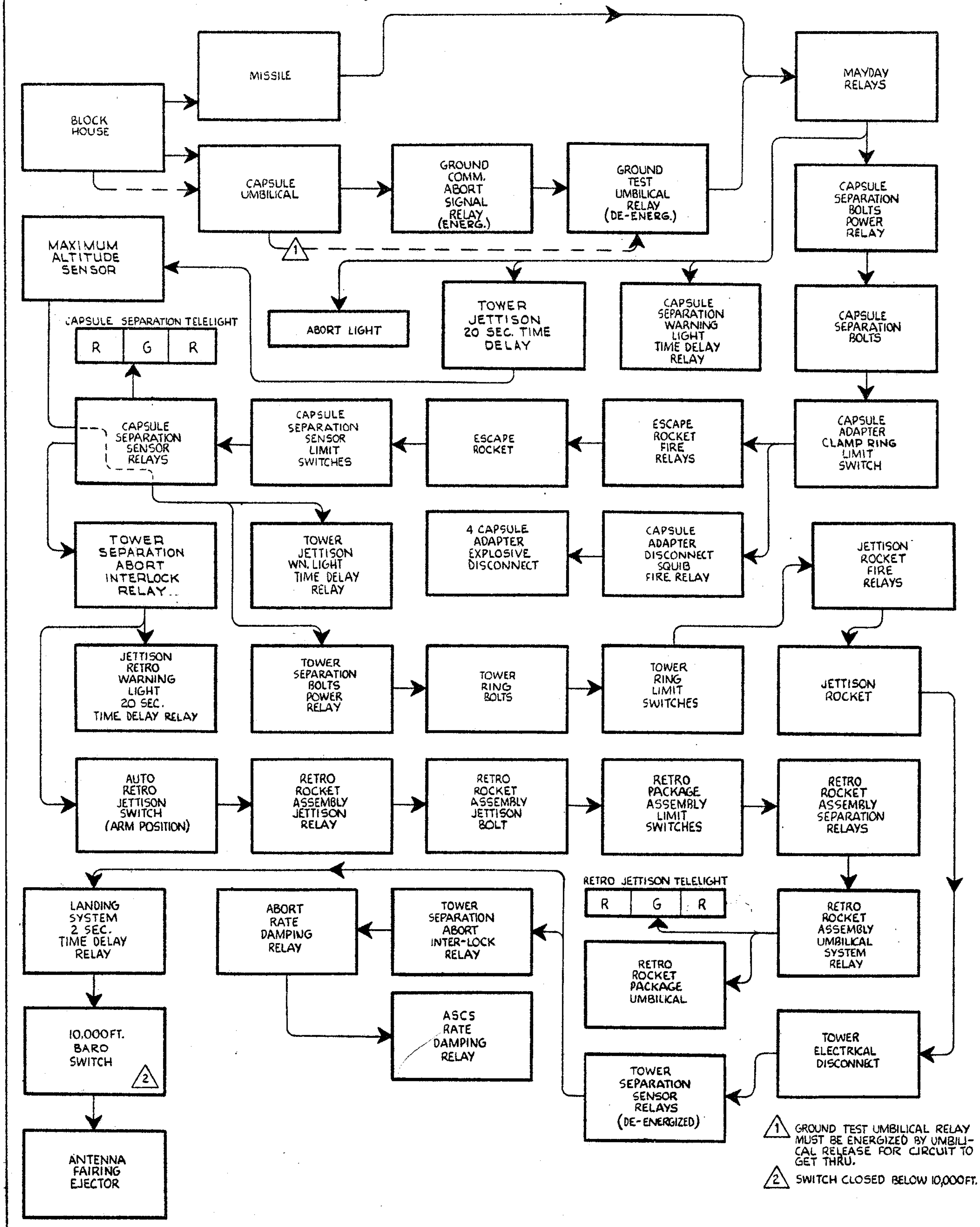


FIGURE 5-6 ESCAPE BEFORE STAGING BLOCK DIAGRAM

PM45-61B

following paragraph.

5-18. Operation

The signal which energizes the Mayday relays also is transmitted to the missile to shut down the sustainer engine (See Figure 5-7 and 5-8). Through contacts of the energized Mayday relays, a power circuit is completed to the ABORT light on the main instrument panel and the .20g contacts of the thrust cutoff sensor are armed. As thrust decays to .20g the contacts close and energize the Capsule Separation Bolts Power relay firing five capsule separation bolts squibs and separating the capsule adapter clamp ring. The sequence following clamp ring separation is the same as the normal sequence (Refer to Paragraph 5-7). Re-entry may be accomplished by any of the emergency procedures (i.e., Astronaut or ground initiated). Refer also to Paragraph 5-9. If the abort is initiated before the capsule has obtained the correct velocity for orbital flight and it is not desired to fire the retro rockets, the retro package must be jettisoned manually. It should be noted that even if the capsule does not attain orbital velocity the quickest way for re-entry is by emergency firing of retro rockets.

5-19. TEST CONFIGURATION CAPSULES

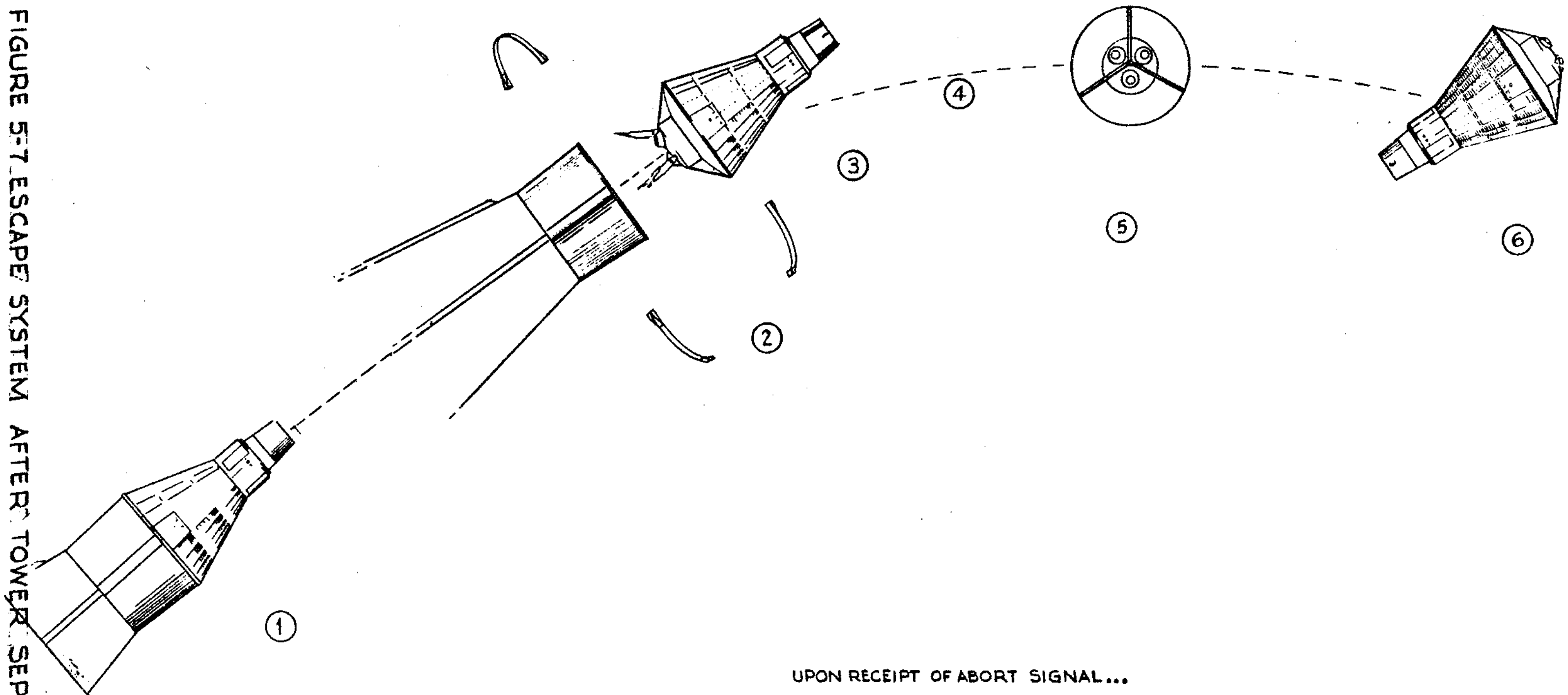
5-20. TEST CONFIGURATION CAPSULE NO. 8

5-21. General

Capsule No. 8 is the same as Specification Compliance Capsule in the sequence of events that takes place; however, the circuitry of the Launch Orbit and Escape and the Retrograde Relay panels differ in the following manner.

5-22. Launch Through Second Staging

Same as Specification Compliance Capsule, except that immediately upon firing the Tower bolts, the Tower Ring limit switches spring to their actuated



UPON RECEIPT OF ABORT SIGNAL...

1. SHUT OFF SUSTAINER ENGINE.
2. SENSE THRUST DECAY TO .20G AND FIRE CAPSULE ADAPTER BOLTS.
3. SENSE CLAMP RING RELEASE, FIRE CAPSULE TO ADAPTER EXPLOSIVE DISCONNECTS AND FIRE POSIGRADE ROCKETS.
4. SENSE CAPSULE-ADAPTER SEPARATION. START 5 SEC. RATE DAMPING, AND JETTISON RETRO-PACKAGE.
5. AFTER 5 SEC. RATE DAMPING CAPSULE TURNS AROUND.
6. ASTRONAUT OR GROUND COMMAND INITIATES EMERGENCY PROCEED-URES TO PERFORM RE-ENTRY AT 34° ATTITUDE.

FIGURE 5-7 ESCAPE SYSTEM AFTER TOWER SEPARATION

PH45-7C

~~CONFIDENTIAL~~

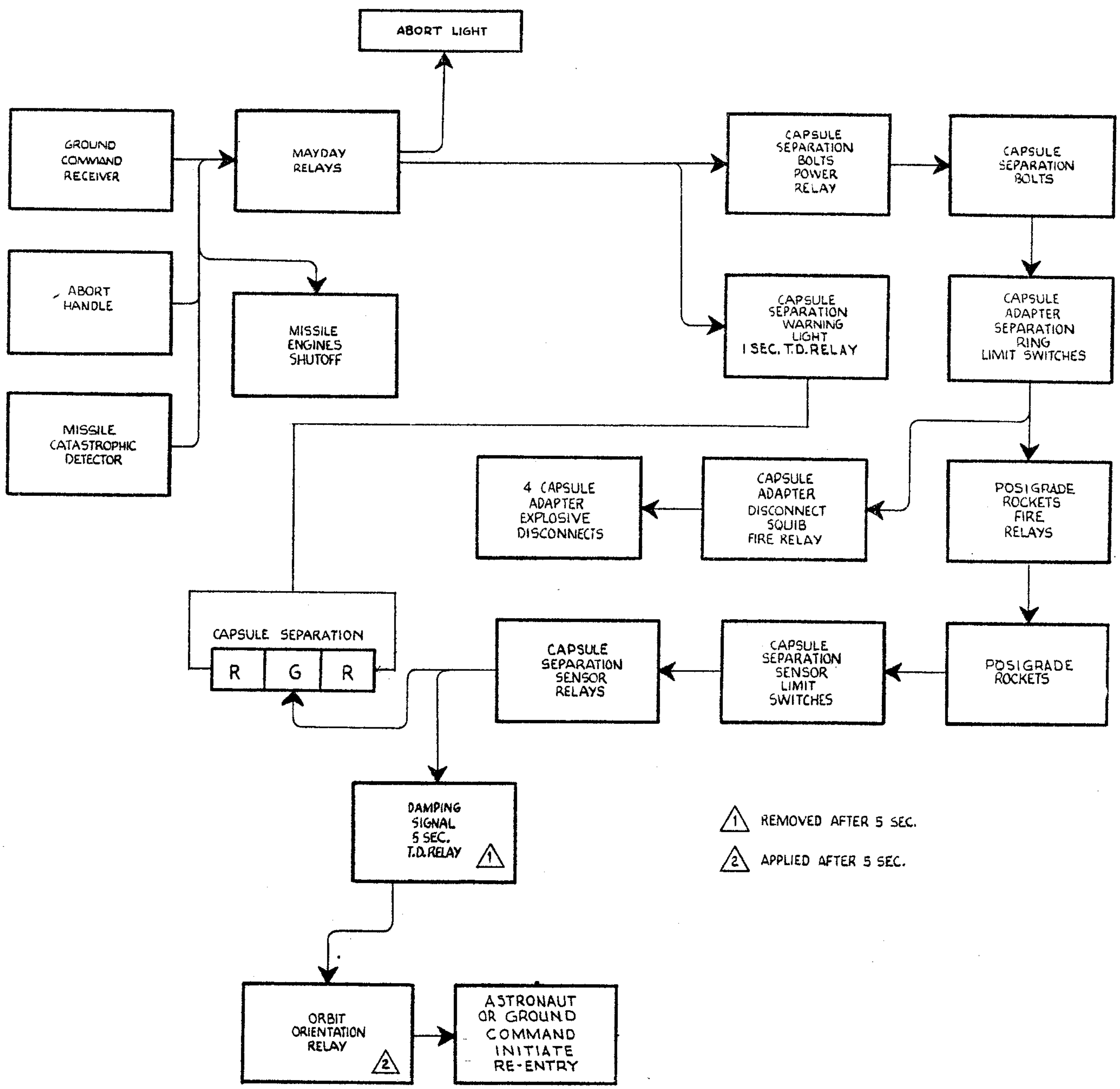


FIGURE 5-8 ESCAPE SYSTEM AFTER TOWER SEPARATION (BLOCK DIAGRAM)

PM45-60B

~~CONFIDENTIAL~~

position and complete a circuit to the Emergency Jettison and Jettison Rocket Fire relays and to the Emergency Escape and Escape Rocket Fire relays. Through these four relays which are connected in parallel for each rocket circuit, the rockets are fired and the tower separates from the capsule.

5-23. Re-Entry

The same as Specification Capsule except that the velocity sensor is replaced by three pressure switches, one on each Retro Rocket. Closing of these pressure switches energize three Retro Rocket Gone Relays which extinguish the Red Retro Telelight and illuminate the green Retro Telelight.

5-24. TEST CONFIGURATION CAPSULE NO. 9

5-25. General

Capsule No. 9 is the same as the Specification Compliance Capsule in the sequence of events that take place; however, the circuitry in the Retrograde Relay panels differ in the following manner:

5-26. Re-Entry

The Retro Rocket Fired Relay which extinguishes the Red Retro Fire telelight and illuminates the Green light is energized by a pressure switch located on the Right (No. 3) Retro Rocket in place of the Velocity Sensor. All the Retro telelights are extinguished through a series of relays except the Retro Jettison light which remains on.

5-27. TEST CONFIGURATION CAPSULE NO. 13

5-28. General

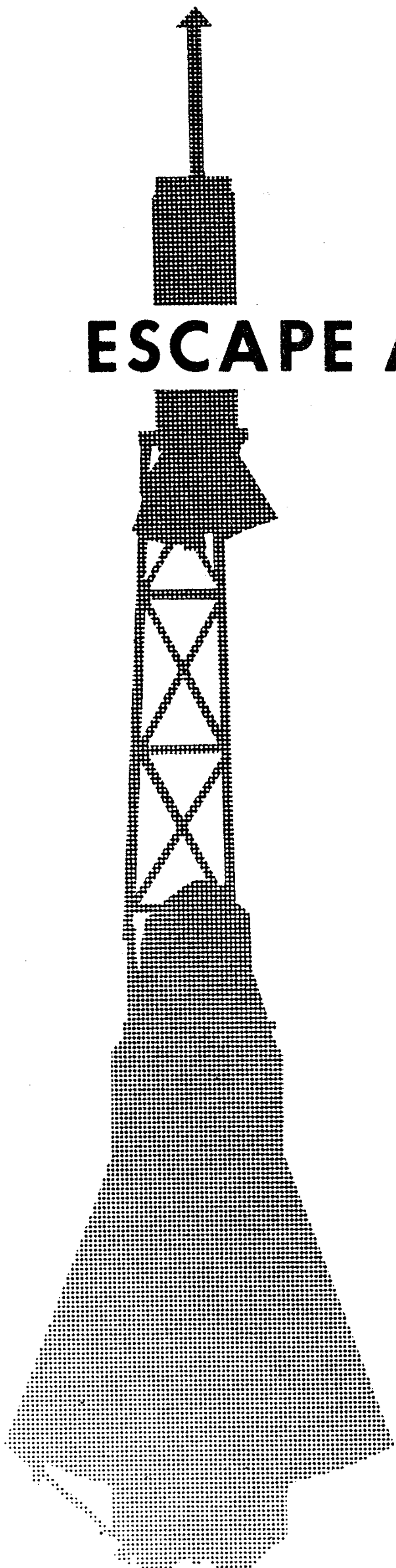
Capsule No. 13 is the same as the Specification Compliance Capsule in the sequence of events that take place; however, the circuitry in the Retrograde relay panels differ in the following manner:

5-29. Re-Entry

The Retro telelights are extinguished through a series of relays except that the .05g Retro Telelight Power Drop relay is not in the circuit and the Retro Jettison light remains on.

5-30. TEST CONFIGURATION CAPSULES NO. 10 AND 16

Capsules No. 10 and 16 are the same as Specification Capsules.



SECTION VI

ESCAPE AND JETTISON ROCKET SYSTEMS

TABLE OF CONTENTS

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

CONFIDENTIAL

DATE 1 NOVEMBER 1961
REVISED
REVISED

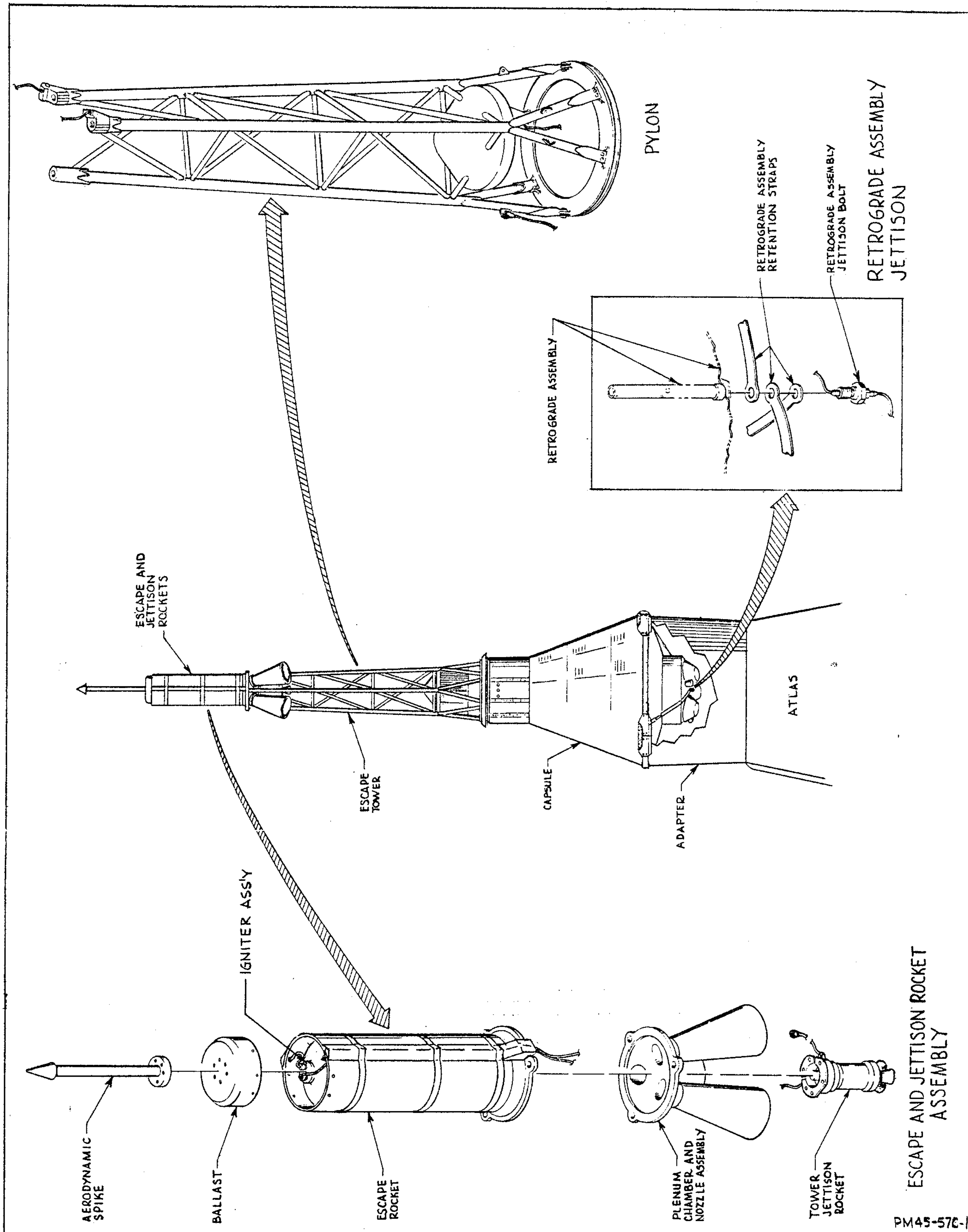


FIGURE 6-1 ESCAPE SYSTEM (SHEET 1 OF 2)

CONFIDENTIAL

VI. ESCAPE AND JETTISON ROCKET SYSTEM

6-1. SYSTEM DESCRIPTION

The escape system consists of the capsule pylon, escape rocket and pylon jettison rocket. The system also utilizes items illustrated on Figure 6-1. These items are not part of the escape system, but assist in the sequence of events to complete the escape function. During normal flight conditions where an abort is never initiated, all of the associated items perform their same function but in different sequences. For a written description of the escape system and diagrams of the items under discussion, refer to Section V.

6-2. SYSTEM OPERATION

The capsule electrical system provides for an abort any time after the gantry is removed. When an abort is initiated, the capsule adapter clamp ring is released, the escape rocket ignited, and the capsule is carried to an altitude of approximately 2500 feet. At this time, by means of the altitude sensor, the capsule tower clamp ring is released, the tower jettison rocket ignited, and the escape tower jettisoned. Two seconds after tower jettisoning, the drogue chute is deployed. Two seconds after drogue chute deployment, the antenna fairing is released. Twelve seconds after antenna fairing release, the heat shield is released, extending the landing impact skirt. During a normal mission where the escape system is not utilized, the escape rocket is used to separate the escape tower from the capsule.

6-3. ABORT HANDLE

The abort handle's primary function is to initiate the abort sequence. The handle is also used as a restraint handle during launch. Location of the abort handle is forward of the Astronaut's support couch left arm rest. For

McDONNELL *Aircraft Corporation*
ST. LOUIS, MISSOURI

CONFIDENTIAL

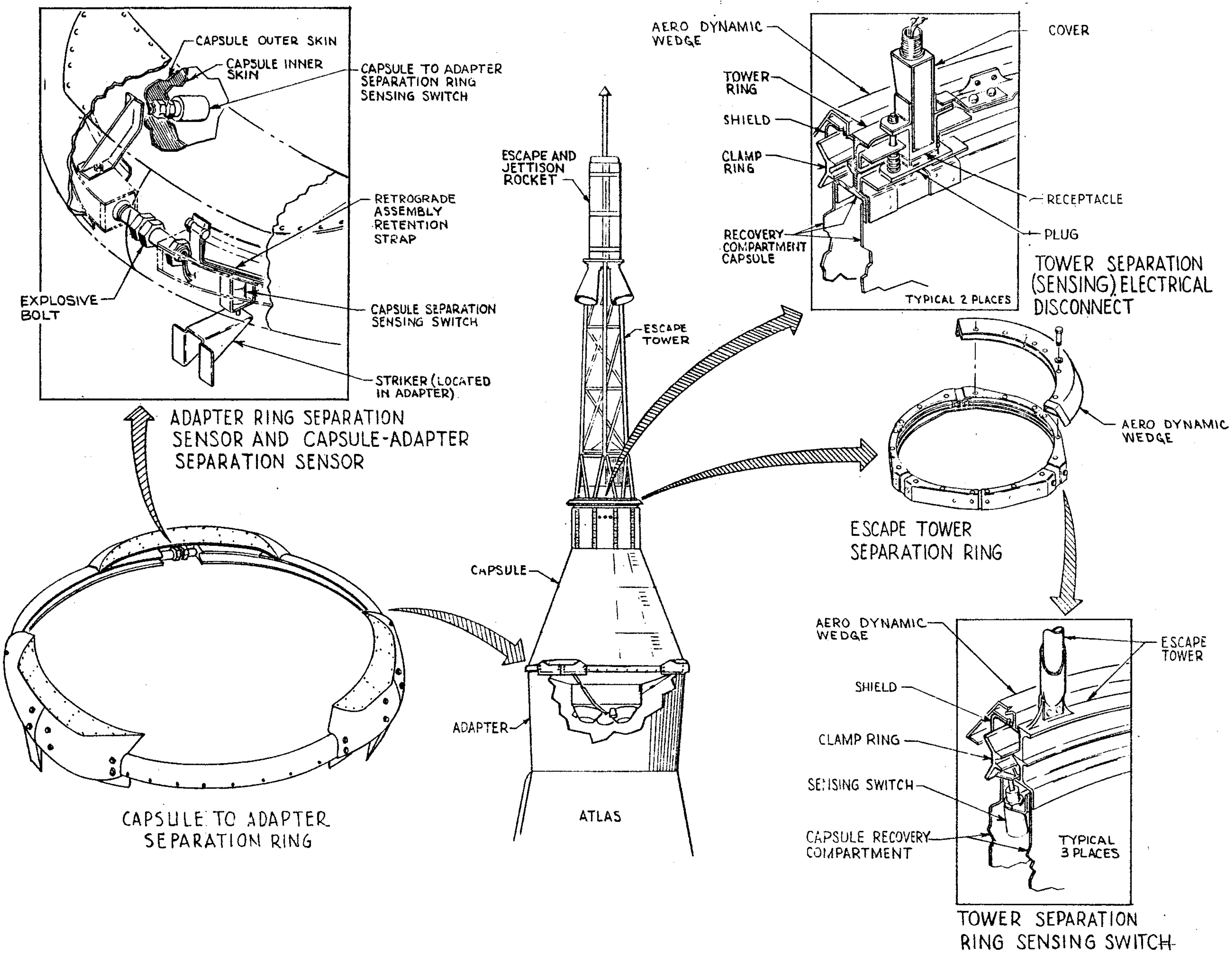


FIGURE 6-1 ESCAPE SYSTEM (SHEET 2 OF 2)

CONFIDENTIAL

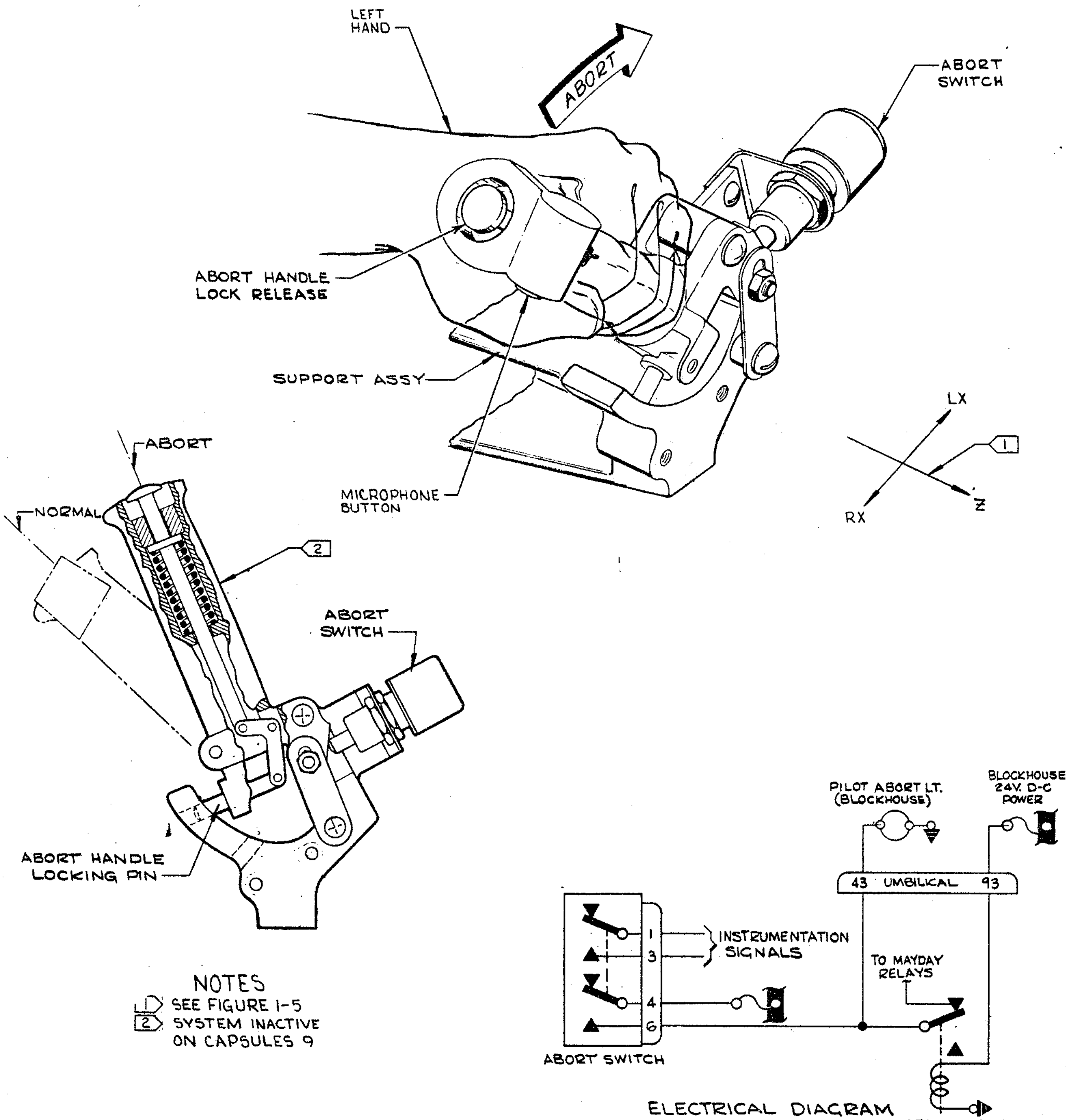
PM45-5TB2

an Astronaut initiated abort, the release button located in the top of the handle must be depressed, allowing the handle to be rotated outboard. When moved to the abort (outboard) position, an electrical switch is actuated, which acts to detonate the capsule-to-adapter clamp ring bolts. The escape sequence is then initiated, providing that the main umbilical has been disconnected. Before umbilical release, the abort handle is inoperative. (See Figure 6-2.)

6-4. ESCAPE ROCKET

The escape rocket consists of an electrically actuated igniter assembly, a $\frac{1}{4}$ inch 4130 steel case, rocket nozzle assembly, plenum chamber and a solid fuel propellant (See Figure 6-4). The length of the escape rocket is approximately 70 inches. The diameter of the rocket case is approximately 15 inches. The weight of the motor prior to firing is approximately 350 pounds. For aerodynamical stability, ballast is added to the top of the rocket (See Figure 6-1 Sheet 1 of 2). The nozzle assembly incorporates three equally spaced exit cones. The exit cones are canted at 19 degrees from centerline of rocket case to centerline of exit cones so as to direct the rocket blast outward and away from the tower and capsule. The plenum chamber incorporates a jettison motor boss which facilitates for the installation of the jettison rocket motor. The jettison motor boss also provides for the attachment of the thrust alignment mirror. The optical sighting of the resultant thrust vector is accomplished by the thrust alignment mirror. For off the pad escapes the rocket will obtain a maximum capsule altitude of approximately 2500 feet.

The escape rocket propellant is a polysulfide ammonium perchlorate formulation which is widely used in the rocket industry. The United States Bureau of Explosives classifies the propellant as a "Class B Explosive". The propellant is sensitive to pressure and a spark or flame may easily ignite it. The



NOTES
1. SEE FIGURE 1-5
2. SYSTEM INACTIVE ON CAPSULES 9

FIGURE 6-2 ABORT HANDLE

PM45-62

propellant grain is an internal burning nine point star which is cast directly into and bonded to the case. With the nine-pointed port design, the possibility of thrust misalignment is reduced. This is due to the improved alignment between the star ports and the exhaust nozzles. The nominal resultant axial thrust at 70 degrees F is 52,000 pounds for 0.78 of a second; it then drops off uniformly to 5000 pounds in the next 0.6 of a second. The thrust will then diminish at a reduced rate to zero. The total impulse of the motor, at sea level, is approximately 56,500 pounds - second.

The escape rocket igniter is a head mounted dual unit with two completely independent initiation systems to each unit. The dual initiation system to each unit has independent circuitry from different batteries. This igniter is cylindrical in shape, and is a central dynaflow type of long duration. This igniter is essentially a miniature rocket motor. It incorporates a small propellant grain which can be ignited by either of two squibs surrounded by boronpotassium nitrate pellets. Surrounding this is an annular plastic tube filled with a metal-oxidant mixture in which are located two sets of four squibs. Either set is capable of initiating the igniter. Each igniter has two initiation systems, either of which can start the igniter in the event some of the squibs are inoperative. The igniter is a Class A Explosive.

6-5. JETTISON ROCKET

The jettison rocket is a qualified Thor retro unit and is manufactured by the Atlantic Research Corporation. The rocket consists of an electrically actuated igniter, a motor case and a tri-nozzle assembly (See Figure 6-5). The nozzle's cones are canted at a 30 degree angle (from centerline of motor case to centerline of exit nozzle). It weights 19.5 pounds, has a length of 18 inches, a diameter of 5.5 inches, and produces 785 pounds of thrust for 1.4 seconds at 70° F. in vacuum. The rocket has been successfully fired from -75° F. to 175° F.,

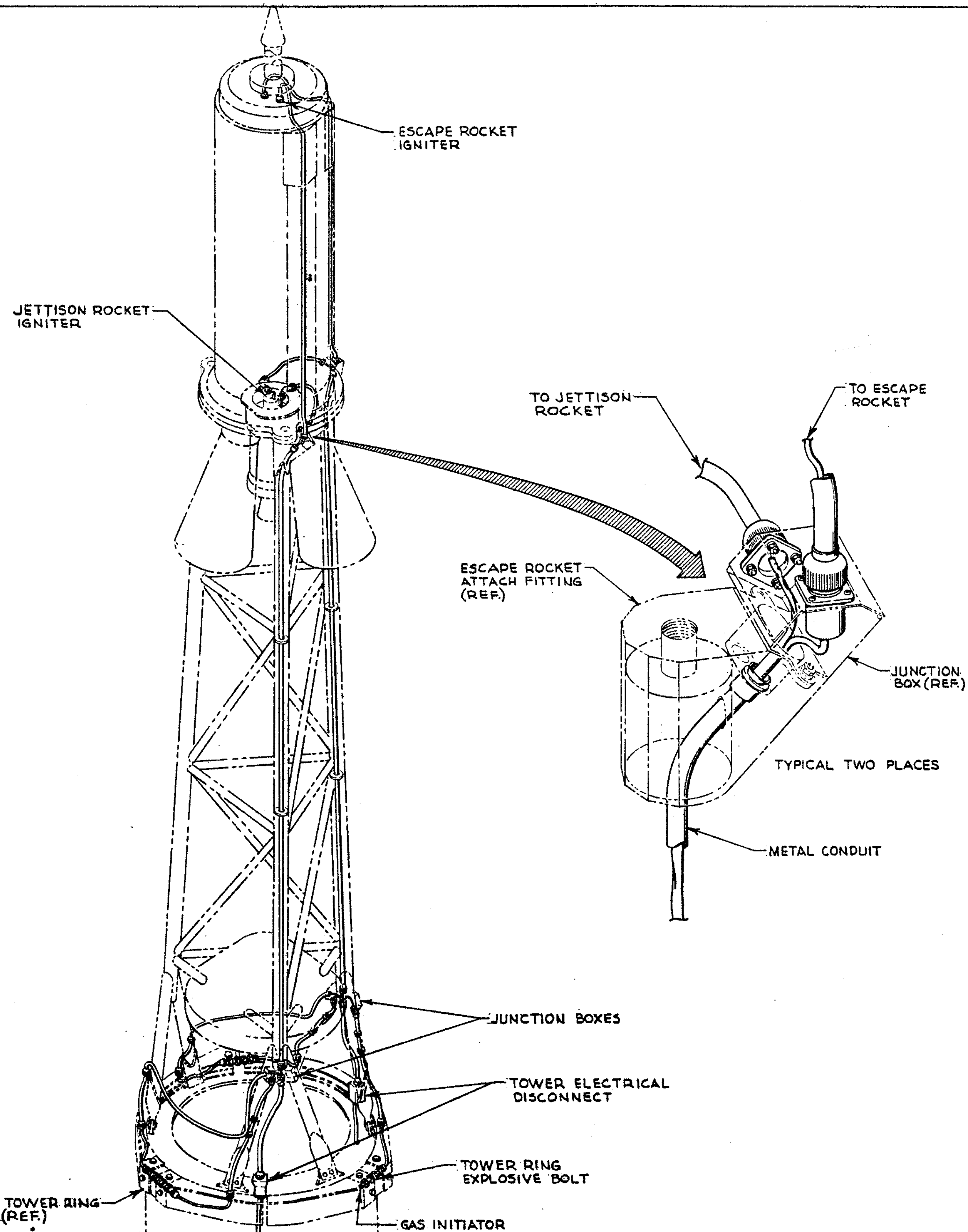


FIGURE 6-3 ESCAPE AND JETTISON ROCKETS ELECTRICAL INSTALLATION PM45-648

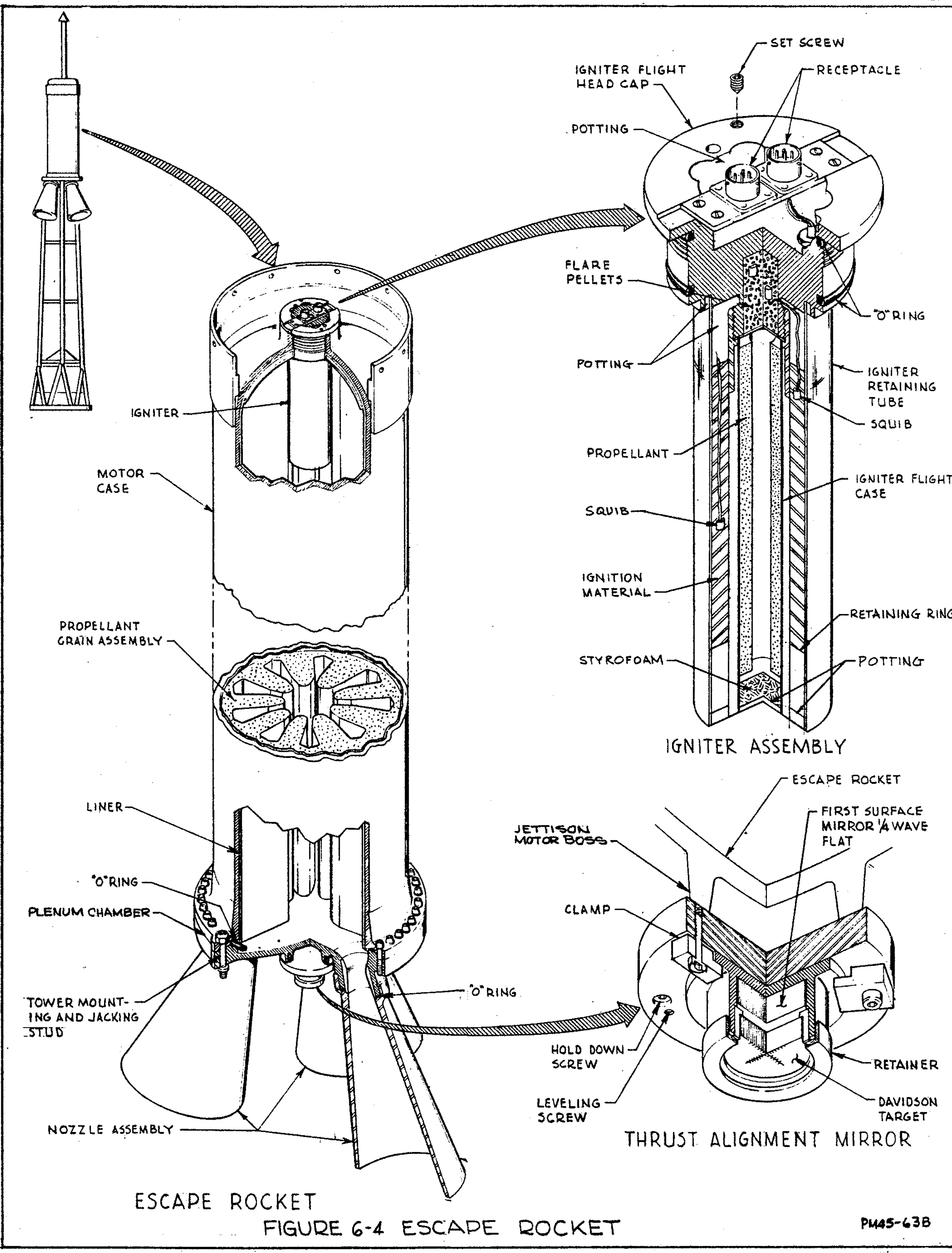


FIGURE 6-4 ESCAPE ROCKET

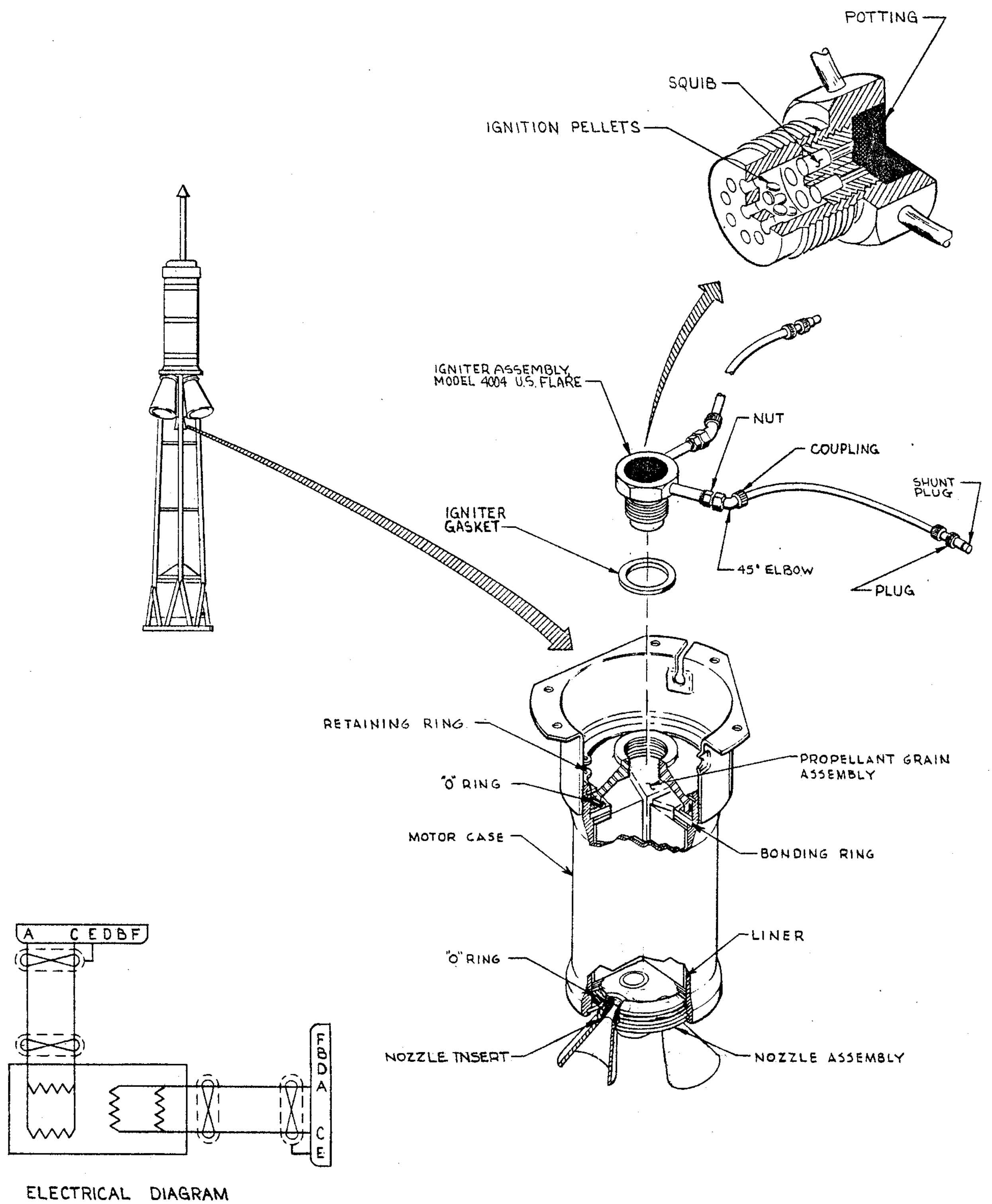


FIGURE 6-5 JETTISON ROCKET

PH45-1328

and from sea level to vacuum.

The jettison rocket igniter is a head mounted unit with dual ignition capabilities. This unit is cylindrical in shape with a hexagonal head and threads into the top of the jettison rocket. The igniter contains approximately 7 grams of USF-2D ignition pellets which are ignited by either of four squibs. Each pair has independent circuitry from a different power source and either pair is capable of igniting the pellets.

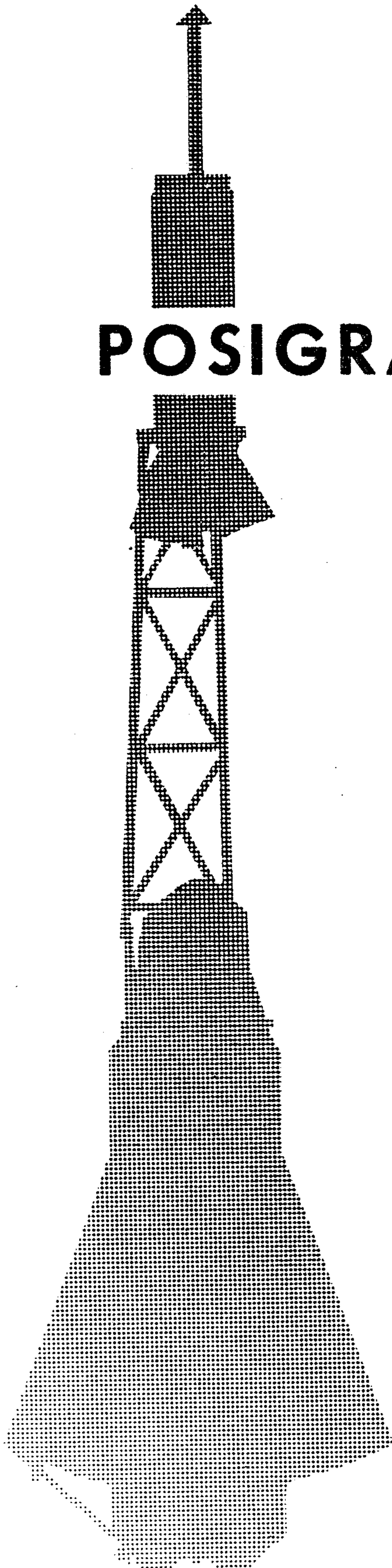
6-6. TEST CONFIGURATION CAPSULES

6-7. TEST CONFIGURATION CAPSULES NO. 8, 10 AND 16

The above capsules differ from the specification capsule in the following manner. For a normal launch, the escape tower will be jettisoned from the capsule by the simultaneous firing of the escape and jettison rockets.

6-8. TEST CONFIGURATION CAPSULES NO. 9 AND 13

Same as specification capsule.



SECTION VII

POSIGRADE ROCKET SYSTEM

TABLE OF CONTENTS

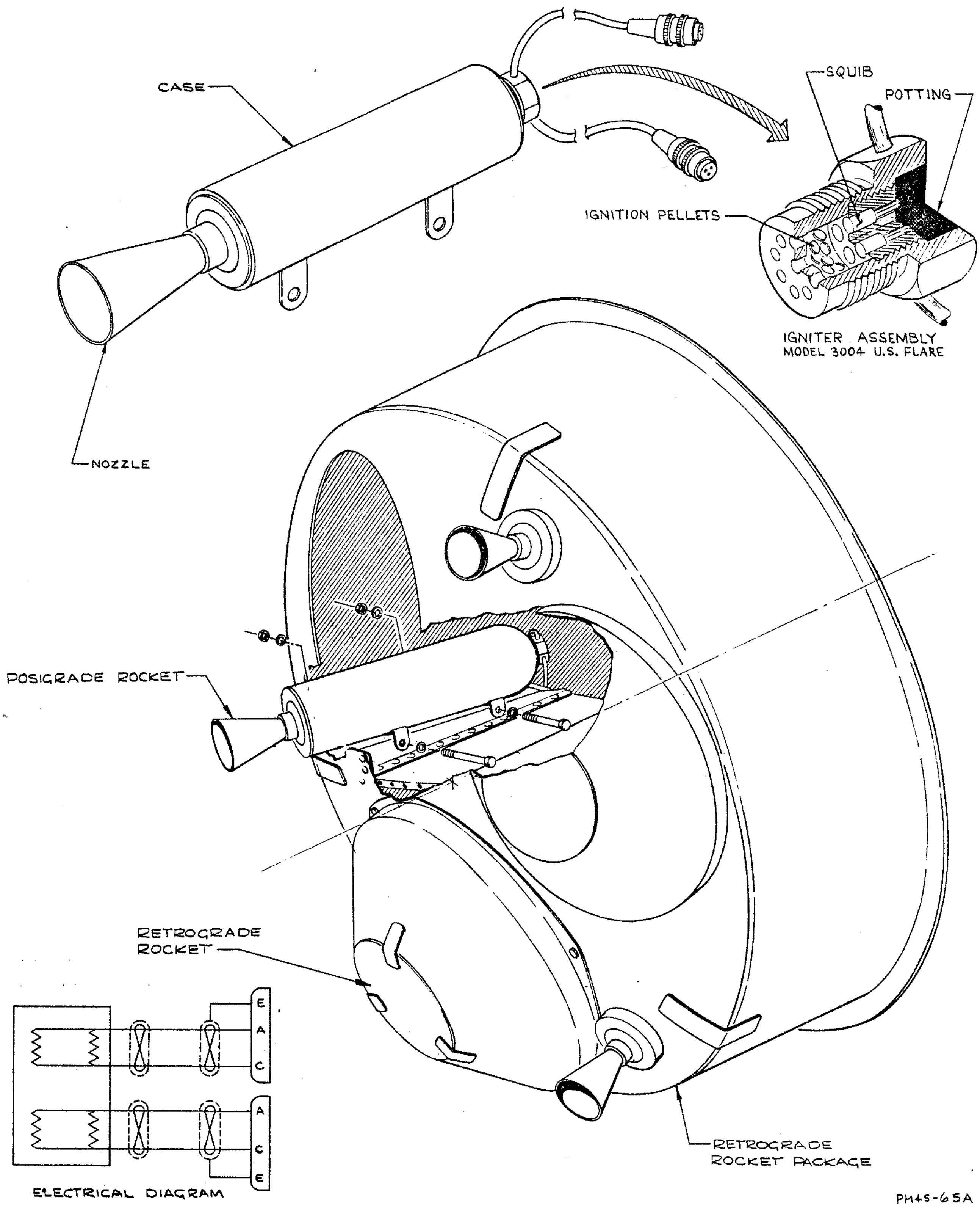


FIGURE 7-1 POSIGRADE ROCKET SYSTEM

VII. POSIGRADE ROCKET SYSTEM

7-1. SYSTEM DESCRIPTION

The posigrade rocket system consists primarily of the three posigrade rockets and igniters mounted in the retrograde package and the associated wiring necessary to ignite the rockets at the proper time. (See Figures 7-1 and 7-2.)

7-2. SYSTEM OPERATION

The purpose of the posigrade rockets is to accomplish separation between the capsule and booster at a rate of 15 feet per second when orbital velocity has been achieved. They also perform the same separation function during an abort after tower separation. The three rockets are fired simultaneously; however, should two of them fail, the remaining unit would successfully affect separation.

7-3. POSIGRADE ROCKET

The posigrade rocket primarily consists of a nozzle assembly and case, a solid propellant and an electrically actuated igniter. It is a cylindrical device measuring approximately 14.7 inches in length, 2.8 inches in diameter and weighing approximately 5.24 pounds. This rocket is basically an Atlas retro-rocket with minor changes for increased reliability. Reliability has been gained by two methods; (a) Dual ignition of the igniter squibs from two different buses, (b) only one of the three rockets is necessary to accomplish successful separation. Due to the wide temperature range of these rockets, a temperature control system is not required. The propellant utilized in the posigrade rocket is Arcite 377 which provides an average thrust of 370 pounds for one second in a vacuum.

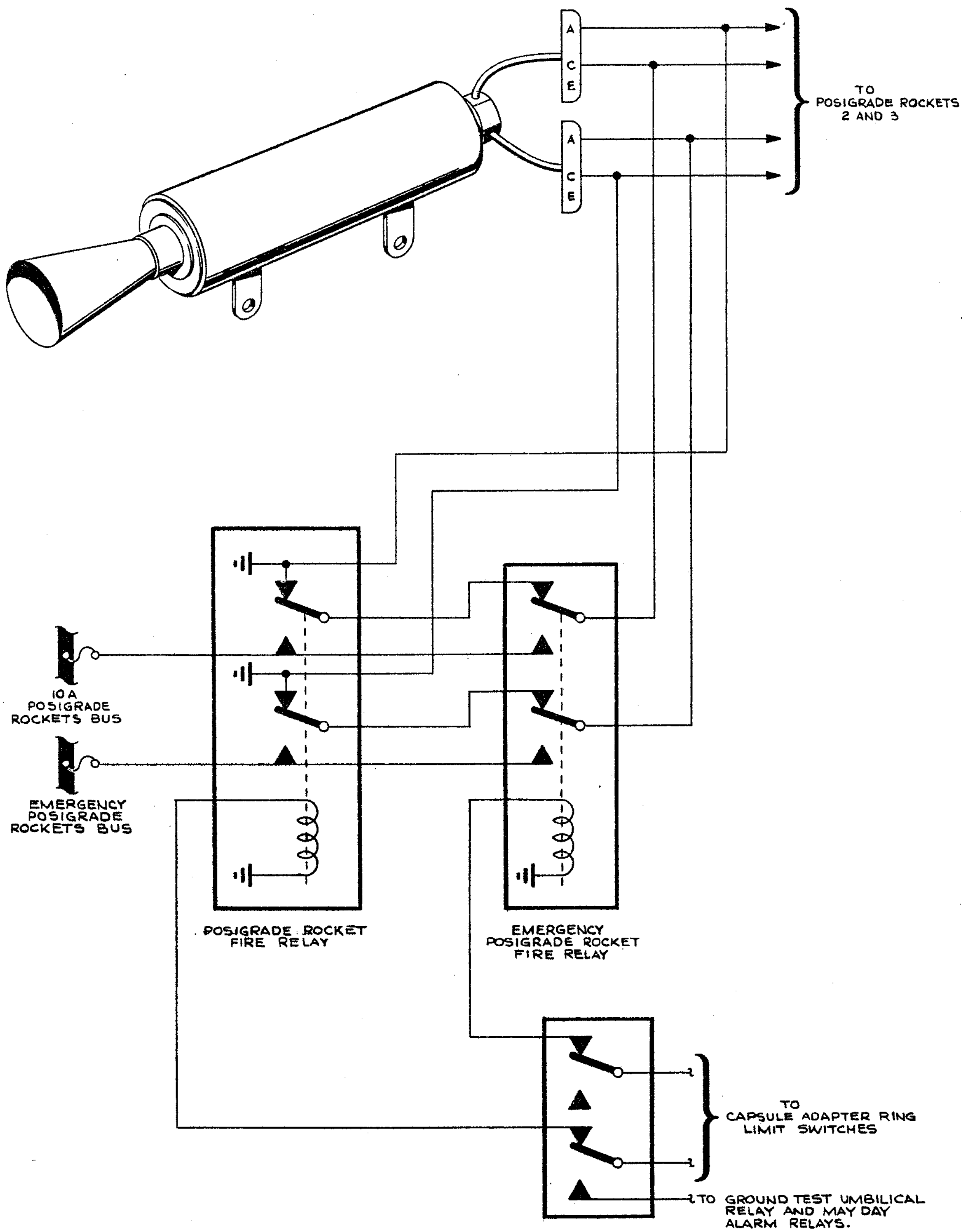


FIGURE 7-2 POSIGRADE ROCKET IGNITION SYSTEM SCHEMATIC

PM45-66A

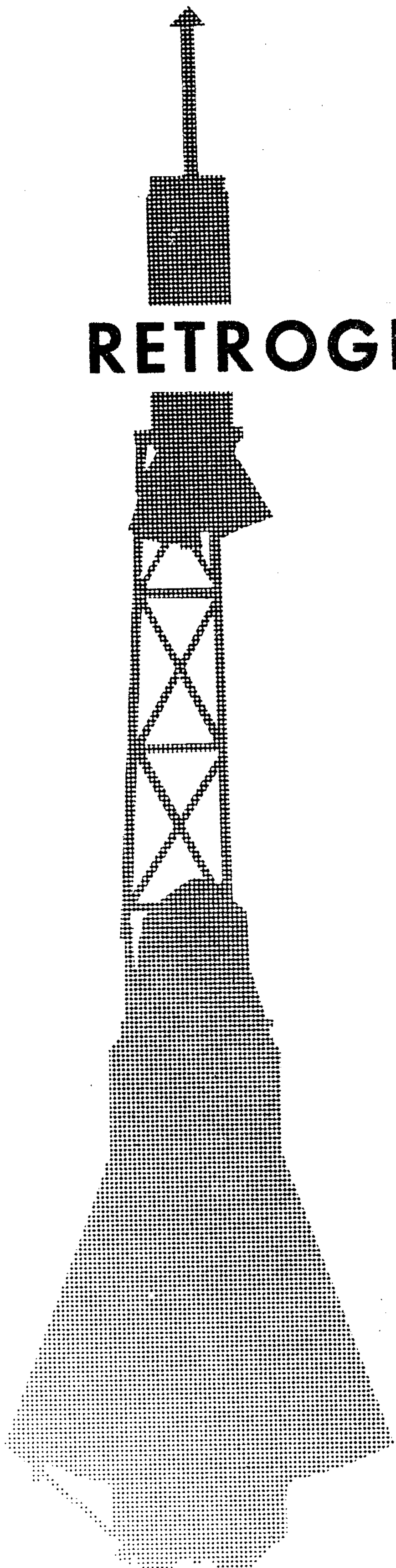
7-4. Rocket Igniter

The posigrade rocket igniter is a head mounted unit with dual ignition capabilities. The igniter is cylindrical in shape with a hexagonal head for threading it into the top of the posigrade rocket (see Figure 7-1). This unit contains approximately 3 grams of ignition pellets which are ignited by either of two pairs of squibs. Each pair has independent circuitry from a different power source and either pair is capable of igniting the pellets.

7-5. TEST CONFIGURATION CAPSULES

7-6. TEST CONFIGURATION CAPSULES NO. 8, 9, 10, 13 AND 16

Same as specification capsule.



SECTION VIII

RETROGRADE ROCKET SYSTEM

TABLE OF CONTENTS

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI
CONFIDENTIAL

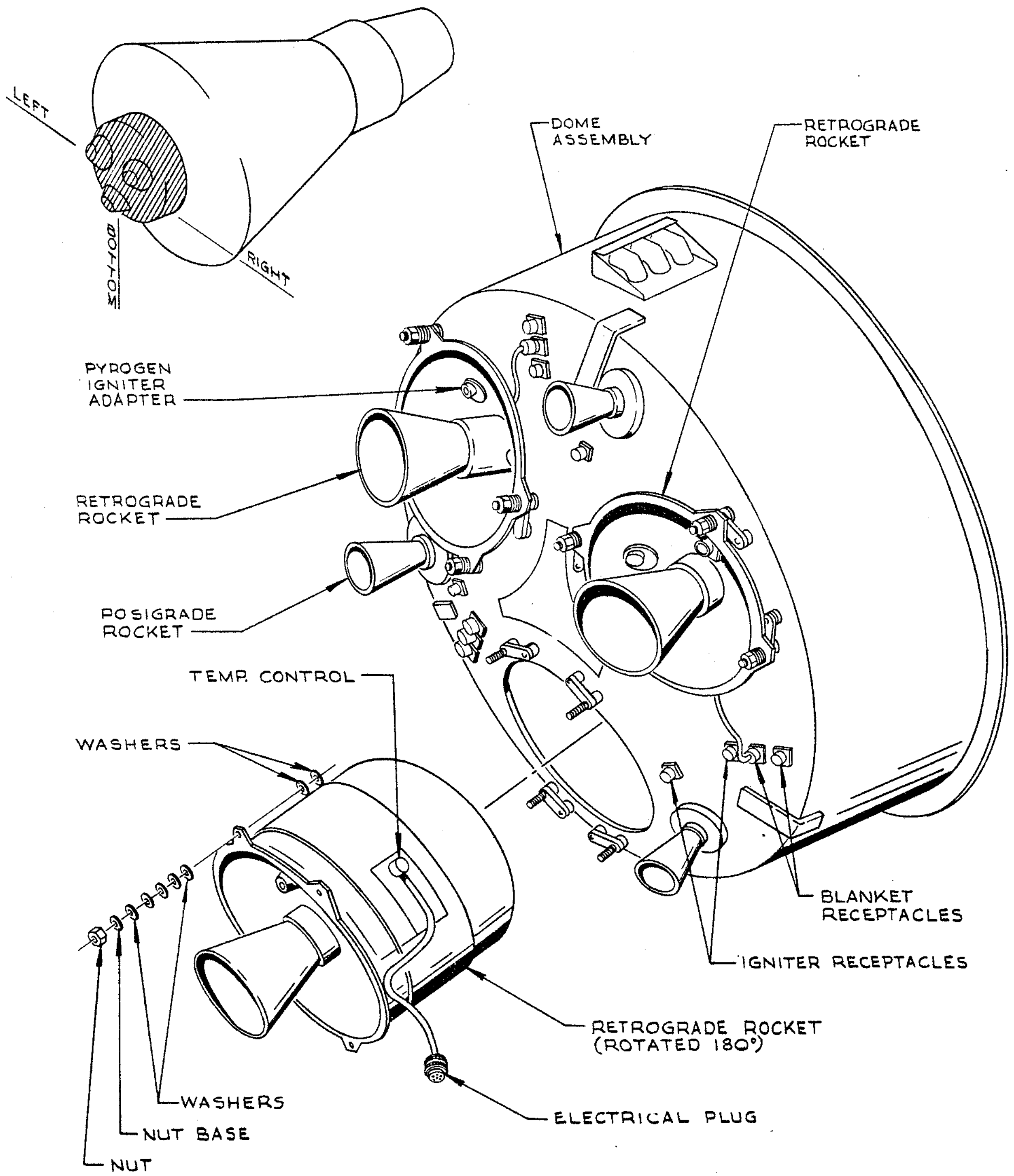


FIGURE 8-1 RETROGRADE ROCKET SYSTEM

PM45-65A

VIII. RETROGRADE ROCKET SYSTEM

8-1. SYSTEM DESCRIPTION

The retrograde rocket system consists primarily of the three retro-rockets, their pyrogen igniters, and the associated wiring necessary for rocket ignition. The retro-rockets are housed in the jettisonable retrograde package along with the posigrade rockets. (See Figure 8-1.)

8-2. ROCKET MOUNTING

The retro-rockets are mounted in the retro-package which, in turn, is mounted to the capsule by means of three straps joined at the bottom center of the package by an explosive bolt. Sixty seconds following retrograde firing signal, the bolt detonates, the straps are released, and a coil spring ejects the package away from the capsule. To protect the rockets, particularly from micro-meteorites, each rocket has a metal cover over its exposed nozzle end. The cover is blown off by rocket blast at time of light-off. Mounting of the rockets is so designed as to direct the resultant thrust vector towards the capsule's predetermined center of gravity at time of firing.

8-3. RETRO PACKAGE ELECTRICAL WIRING

The retro package is supplied electrical power through the three electrical explosive disconnects that are equally positioned around the base of the capsule. Electrical wire bundles from the disconnects follow the three retrograde package retension straps down to the retro package, where they enter this unit through rubber grommets. Within the package all wiring for the retro rockets, sensors and heaters are routed to the outside of the package face and then into each retro rocket through the slotted metal shield. Posigrade rocket wiring and explosive bolt wiring remain within the package. (See Figure 8-4.)

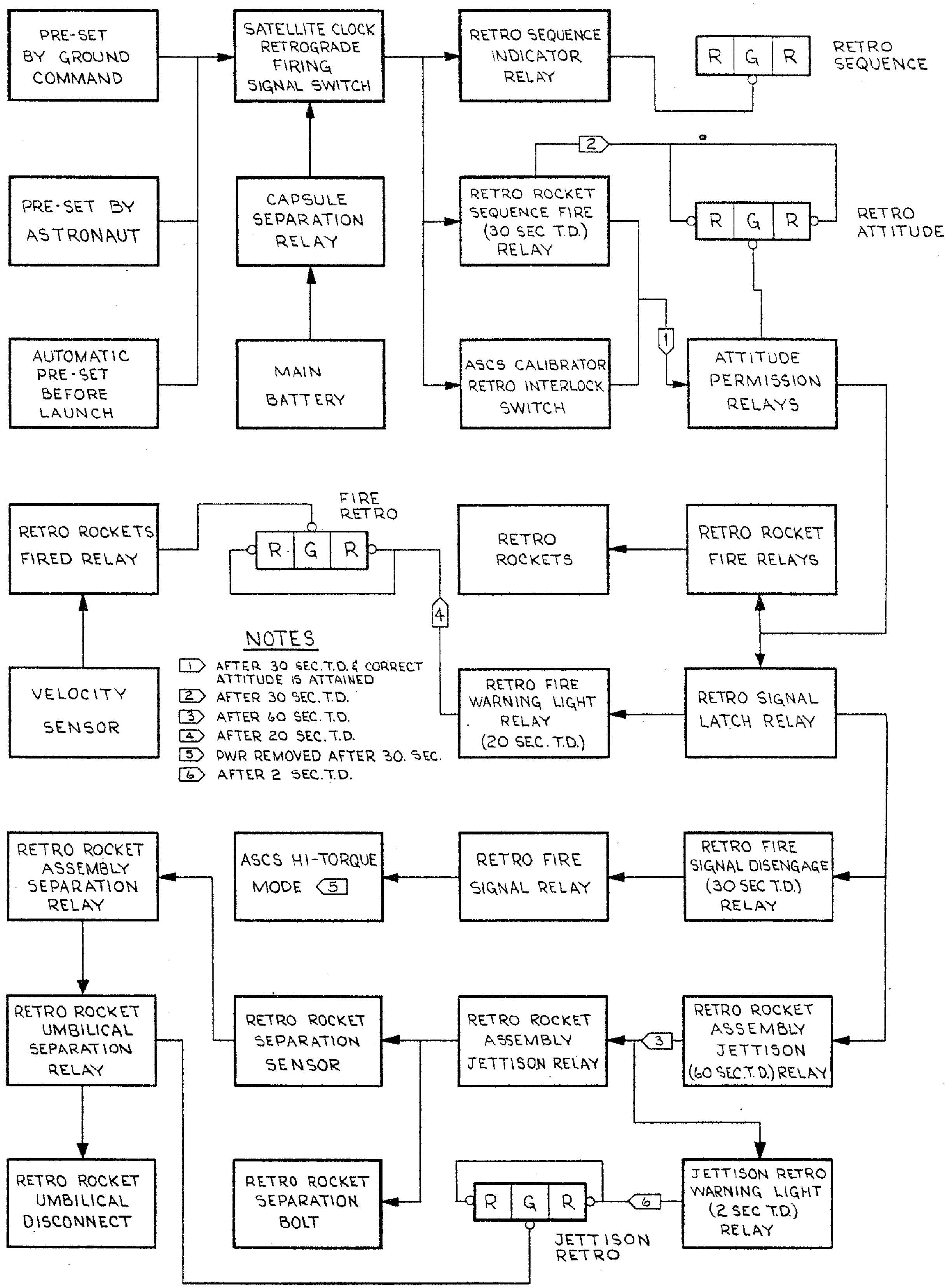
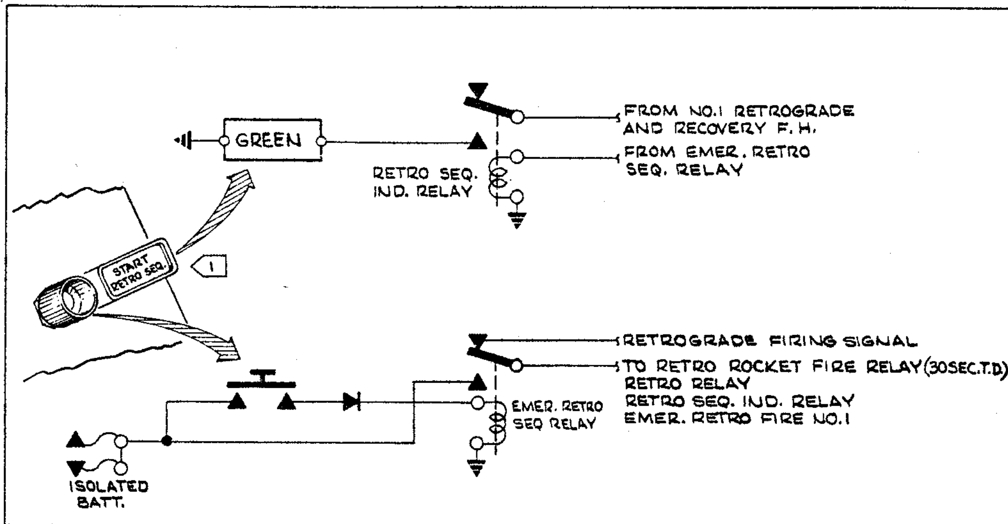
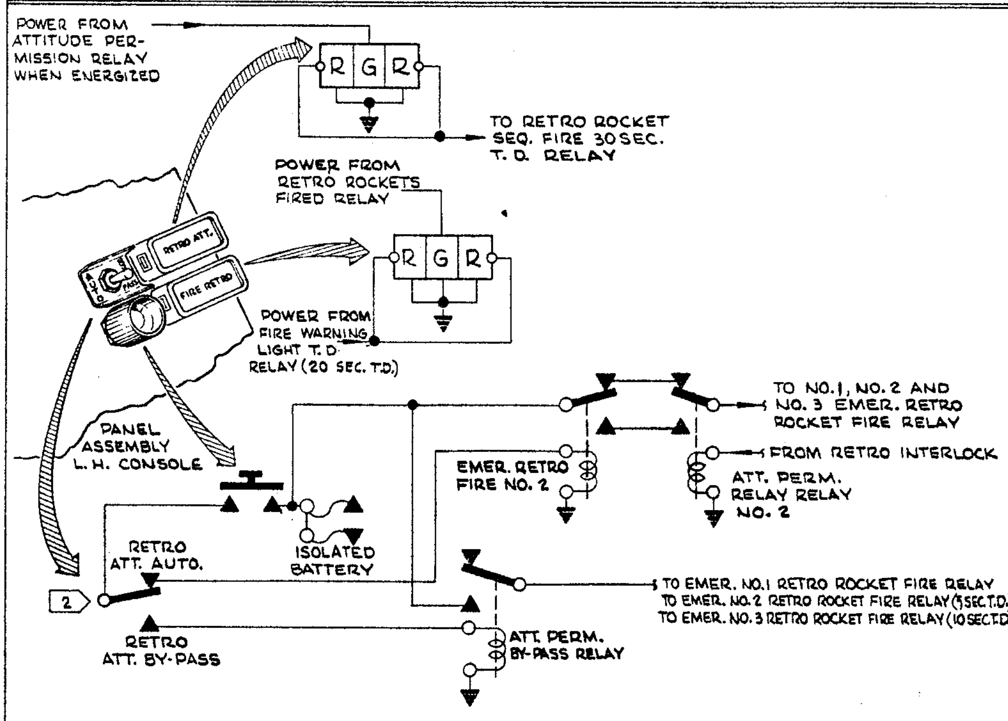


FIGURE 8-2 RETROGRADE ROCKET AUTOMATIC FIRING SYSTEM



REASON FOR SELECTION

1. FAILURE OF SATELLITE CLOCK TO FUNCTION
2. EARLY RE-ENTRY BEFORE CLOCK RUN-OUT.



1. THE "RETRO ATTITUDE" LIGHT DOES NOT ILLUMINATE OR ILLUMINATES RED, BUT VISUAL AIDS INDICATE CAPSULE IS IN RETRO ATTITUDE.

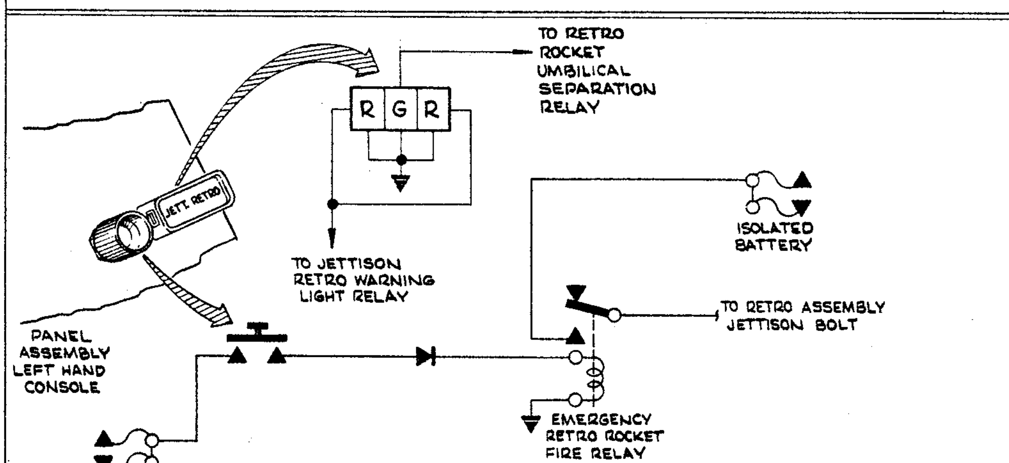


FIGURE 8-3 RETROROCKET OVERRIDE FIRING SYSTEM SCHEMATIC

1. "JETTISON RETRO" LIGHT ILLUMINATES RED.

NOTES

1. GREEN LIGHT ONLY.
2. IF THE "RETRO ATT" LIGHT IS GREEN AND "RETRO FIRE" LIGHT ILLUMINATES RED THE "RETRO ATT" SWITCH SHOULD BE LEFT IN THE "AUTO" POSITION AND THE "FIRE RETRO" BUTTON DEPRESSED. CIRCUITRY WILL PASS THROUGH ENERGIZED ATTITUDE PERMISSION RELAY BUT WILL BY-PASS THE 30 SEC. T. D. SEQ. FIRE RELAY.

PM45-71B

8-4. SYSTEM OPERATION

The purpose of the retrograde rocket system is to slow the capsule prior to re-entry. Actual firing of the rockets is preceded by a 30-second period during which the capsule is positioned to the "retro" attitude. "Retro" attitude is defined as follows: $34^{\circ} \pm 12.5^{\circ}$ Pitch, $0^{\circ} \pm 30^{\circ}$ Roll or Yaw. The firing sequence will not begin, normally, until the "retro" attitude limits have been attained, and will be temporarily interrupted should the capsule exceed the attitude limits after the sequence has begun. Should the need arise, however, the above limits may be manually overridden. Firing of the rockets, which occurs at five-second intervals can be initiated by any of the following: (1) Satellite clock runout; (2) Astronaut selection; (3) Ground command. Any one of the rockets will effect a satisfactory re-entry in the event the other two fail to fire. Sixty seconds after signal for retro fire, the entire retrograde package is jettisoned.

8-5. ROCKET FIRING

All three rocket fire relays receive 24 V d-c simultaneously; however, the No. 2 and No. 3 rocket fire relays have a five- and ten-second time delay, respectively. Therefore, the following table shows when each rocket receives its fire signal and the length of burning time thereafter. Note that the asterisk indicates time of firing.

Left No. 1 RKT *__________+

Bottom No. 2 RKT *__________+

Right No. 3 RKT *__________+

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

SECONDS

The retro rockets are fired sequentially to avoid the ineffective results from a failure of either of the first two rockets. Consequently, if No. 1 rocket failed to a degree which would disrupt the retro attitude position, the ASCS attitude interlock would remove power from the attitude permission relay and also the No. 2 rocket fire relay. The capsule could then be repositioned automatically or manually by the RCS, and upon regaining the 34° position, the No. 2 rocket fire relay would receive power and fire. The same sequence would occur if the No. 2 rocket were to fail. (See Figure 8-2.)

8-6. RETRO ROCKET EMERGENCY OVERRIDE

There are four telelights on the Astronaut's left console which concern the retrograde system. The first one is RETRO SEQ. and is a green function light. This light will illuminate when the retro sequence is started, either by the satellite clock or by the button adjacent to the light. The purpose of the button is to initiate re-entry prior to satellite clock runout or failure of same. (See Figure 8-3.)

The next two telelights in the retrograde sequence are RETRO ATT. and FIRE RETRO. For a normal flight, the RETRO ATTITUDE switch adjacent to the RETRO ATT. light should always be in AUTO. The RETRO ATT. light will illuminate green as soon as the capsule reaches the 34° retro attitude position. Approximately forty seconds later the FIRE RETRO telelight should illuminate green. If the RETRO ATT. telelight illuminates red, the Astronaut must check the capsule attitude in order to determine if the capsule is in correct retro fire position. If the capsule is found to be in the correct attitude, then the Astronaut should position the RETRO ATT. switch in the BY PASS position, and also push the FIRE RETRO button. Ten seconds later the FIRE RETRO light should illuminate green. However, if the Astronaut determined that the capsule was not in the correct position, the fly-by-wire system should be employed in order to correctly position the capsule in the 34° attitude. (See Section IV.) When this is accomplished the RETRO ATT. telelight should illuminate green.

If the RETRO ATT. telelight illuminates green, but the FIRE RETRO telelight illuminates red, the button adjacent to the FIRE RETRO telelight should be pushed leaving the RETRO ATT. switch in the AUTO position.

The fourth telelight is the JETT. RETRO. This telelight will illuminate green 60 seconds after the illumination of the FIRE RETRO telelight. In the event this light illuminates red, the adjacent button should be selected to supply an alternate source of power to the jettison bolt. If the retro package cannot be jettisoned by the automatic or override method, it will be ejected sometime during re-entry when the extreme heat encountered will detonate the explosive bolt or burn the retention straps to allow the coil spring to eject the package.

8-7. RETRO ROCKET HEATERS

The retrograde rockets are equipped with blanket type heaters operated by means of ground power only. A resistor type thermostat maintains heater temperature between $75^{\circ} \pm 5^{\circ}$F and $95^{\circ} \pm 5^{\circ}$F preventing moisture from collecting on the retro-rocket nozzle closures.

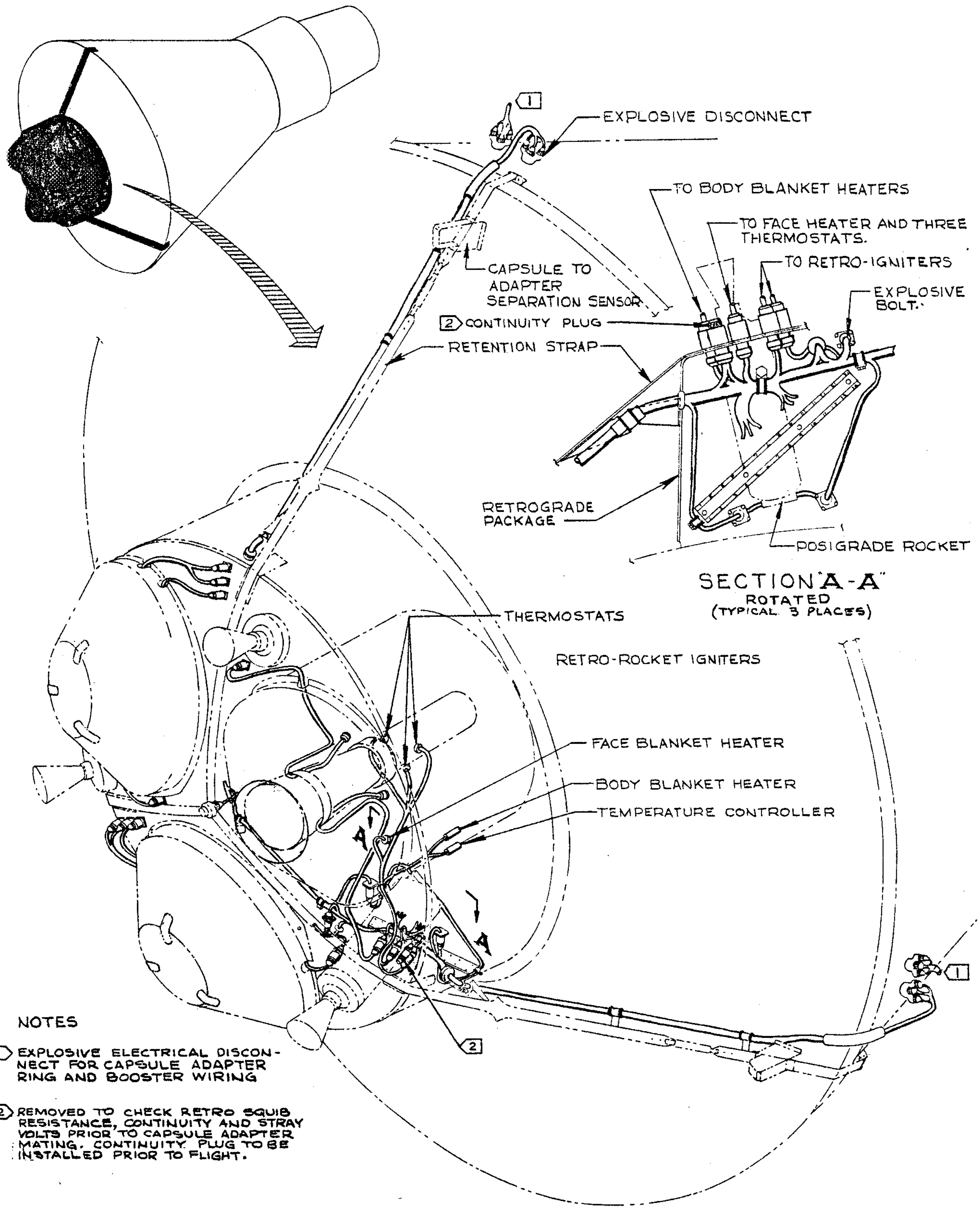
8-8. RETROGRADE ROCKET

The retrograde rocket, manufactured by Thiokol Chemical Corporation, is a variation of the Model TE-236. Leading particulars are: Total weight approximately 69.55 pounds, length 15.4 inches, diameter 12 inches. These rockets have a total impulse of approximately 13,000 pound seconds, providing an average thrust of 992 pounds each for 13.2 seconds action time. Due to the importance of the retrograde system to the overall mission, a redundant rocket firing system has been employed. Dual ignition to all igniters has been provided from separate electrical sources. Heaters are bonded to motor case and nozzle closure and are thermostatically controlled.

8-9. TEST CONFIGURATION CAPSULES

8-10. TEST CONFIGURATION CAPSULES NO. 8, 10, 13 AND 16

The above listed capsules are basically the same as the specification capsule.



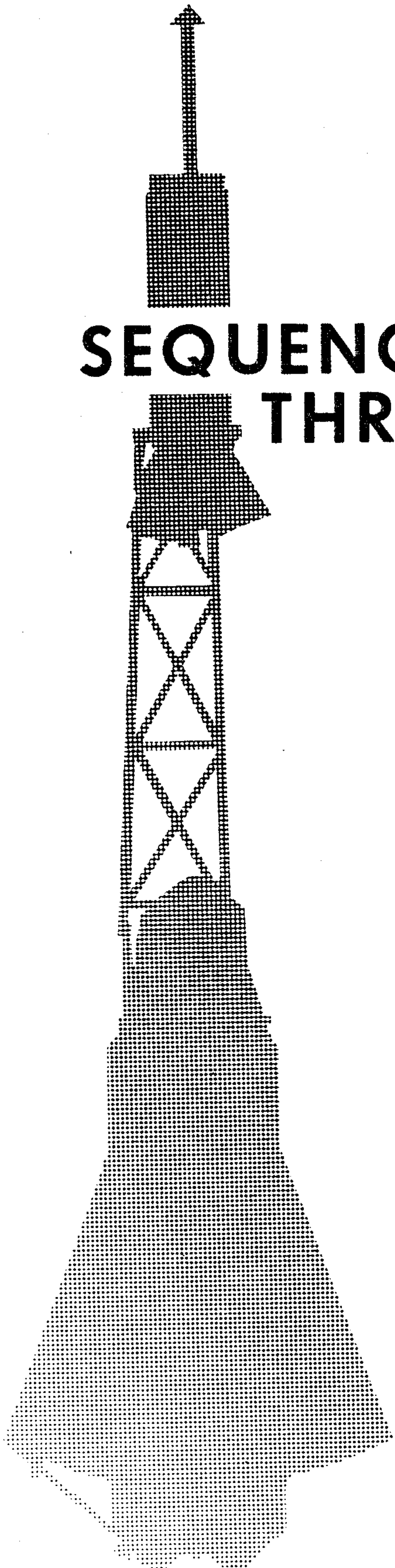
NOTES

1. EXPLOSIVE ELECTRICAL DISCONNECT FOR CAPSULE ADAPTER RING AND BOOSTER WIRING
2. REMOVED TO CHECK RETRO SQUIB RESISTANCE, CONTINUITY AND STRAY VOLTS PRIOR TO CAPSULE ADAPTER MATING. CONTINUITY PLUG TO BE INSTALLED PRIOR TO FLIGHT.

FIGURE 8-4 RETRO PACKAGE ELECTRICAL INSTALLATION

PM45-73

SECTION IX



SEQUENCE SYSTEM LANDING THROUGH RECOVERY

TABLE OF CONTENTS

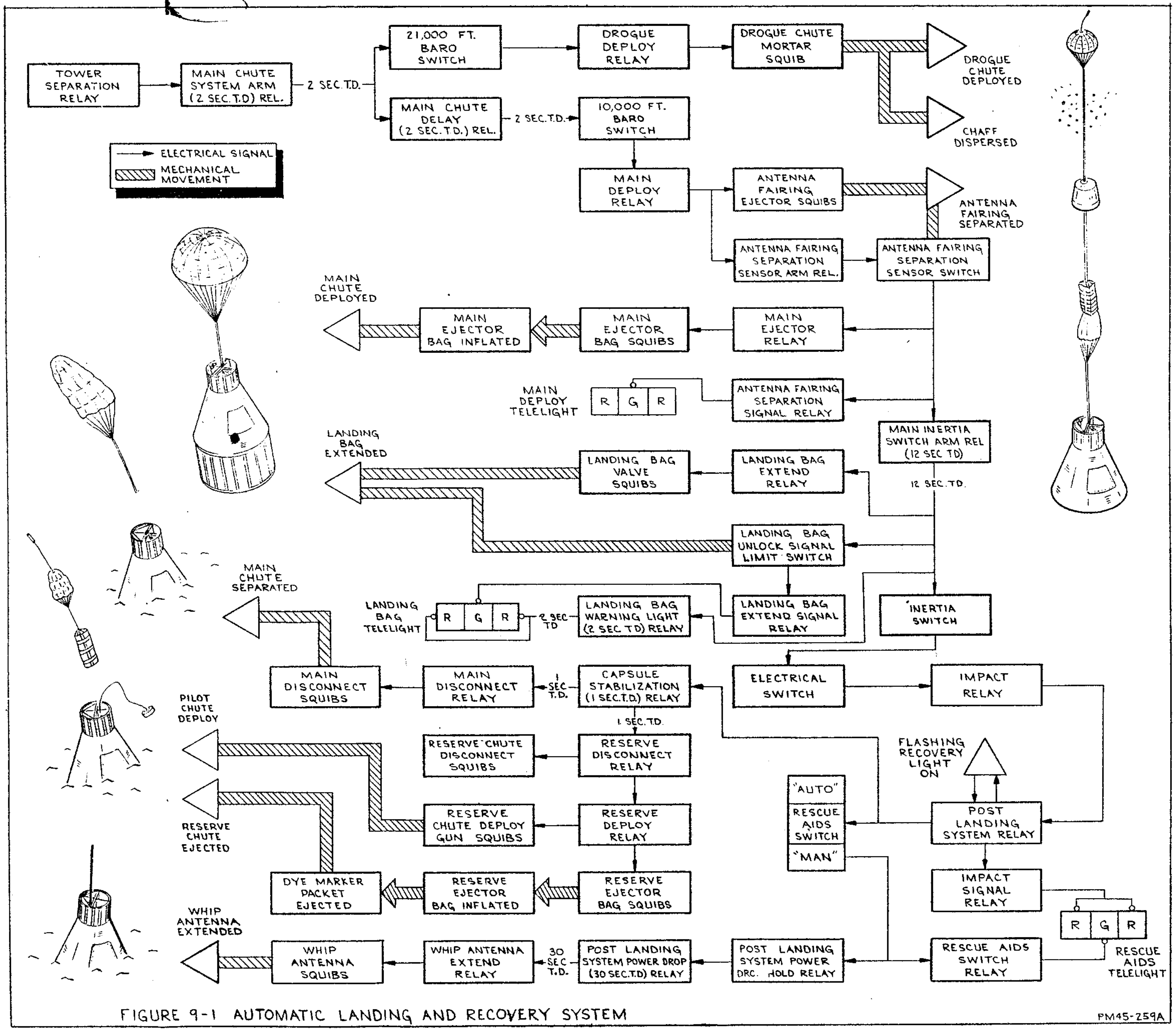


FIGURE 9-1 AUTOMATIC LANDING AND RECOVERY SYSTEM

IX. SEQUENCE SYSTEM LANDING THROUGH RECOVERY

9-1. AUTOMATIC SEQUENCE DESCRIPTION

The landing and recovery sequence system provides automatic electrical sequencing to land the capsule safely after an abort or after re-entry, and to initiate locating aids for assistance in the subsequent recovery. The primary (completely automatic) system incorporates a drogue parachute, used initially to decelerate and stabilize the capsule in the initial phase of recovery and a main parachute which further decelerates the capsule. Capsule landing is accomplished by a 63 foot diameter parachute which is deployed at 10,000 feet. In the event of a main chute failure, a 63 foot diameter reserve chute may be deployed by the Astronaut's manual selection. Both main and reserve chutes are reefed to limit shock loads at initial opening. Automatically, the reefing line is severed after a predetermined time delay and the chute will open fully, lowering the capsule at the prescribed landing speed. After main chute deployment, the landing impact bag is extended, providing a cushioning effect for the landing impact. Immediately after impact, the main chute is automatically disconnected and the reserve chute ejected. The Astronaut will then egress normally taking with him the survival kit which contains a life raft and other survival aids.

9-2. AUTOMATIC SEQUENCE OPERATION

On tower separation, power is removed from the Tower Separation Relays allowing the Main Chute System Arm 2 Second Time Delay relays to be energized (See Figure 9-1). After the 2 second time delay has run out power flows through the closed contacts energizing the Main Chute Delay 2 Second Time Delay relays which in turn after a 2 second delay arms the 10,000 ft. Baroswitch. The 21,000 ft. Baroswitch is armed through the closed contacts of the Main Chute System Arm

2 Second Time Delay relays. Upon descent to 21,000 ft. the 21,000 ft. Baroswitch is actuated, energizing the Drogue Deploy relay, firing the Drogue Chute Mortar, deploying the Drogue Parachute, and ejecting the chaff package. The Drogue Chute stabilizes and decelerates the capsule; the chaff package disperses finely cut metal foil that provides an enlarged radar reflection area that can be picked up by search planes hundred of miles distant. At approximately 10,000 ft. the 10,000 ft. Baroswitch actuates the Main Deploy relay resulting in the removal of ground circuits and firing of all four squibs of the Antenna Fairing Ejector. Also, the Main Deploy Warning Light 2 Second Time Delay relay is actuated, and at the end of 2 seconds delay the Red Main Deploy Telelight is illuminated. The Antenna Fairing Separation Sensor Arm relays are energized through the closed contacts of the Main Deploy relays arming the two Antenna Fairing Separation Sensor Switches.

The firing of the four Antenna Fairing Ejector Squibs causes the Antenna Fairing to separate from the capsule. A lanyard, connected from the Antenna Fairing to the Main Chute, extracts the Main Chute from the chute compartment. The Main chute opens initially in the reefed condition to limit shock loads. Four seconds after the chute is deployed the reefing line is severed by a pyrotechnic charge in the reefing line cutters allowing the parachute to open fully.

The separation of the fairing from the capsule allows the Antenna Fairing Separator Sensor Switches to function. Through the switches, power is routed to energize the Main Ejector Relay firing the Main Ejector Bag Squibs. When the squibs fire, they generate a gas, filling the Ejector Bag at the bottom of the Main Chute compartment aiding the ejection of the chute. At the same time the Antenna Fairing Separation Signal relay is energized, illuminating the Green Main Deploy Telelight and removing power from the Red Telelight. Power is also directed through the Antenna Fairing Separation Sensors to energize the Main Inertia Switch Arm 12 Second Time Delay relays. After the 12 second time delay the energized contacts allow power to be supplied to energize the Landing Bag Extend and Landing Bag Warning Light 2 Second Time Delay relays as well as power to the Landing Bag Unlock Signal Limit Switch and Inertia switch. The closed contacts of Landing Bag Extend relay fire the squibs of the Landing Bag Valve releasing the heat shield and extending the impact landing bag. As the 2 second time delay runs out the Landing Bag Warning Light relay illuminates the Red Landing Bag telelight. Upon heat shield separation the Landing Bag Unlock Signal Limit switch is actuated and through its closed contacts power is directed to energize the Landing Bag Extend Signal relay illuminating the Green Landing Bag Telelight and extinguishing the Red light. The force of impact on landing operates the Inertia Switch and in turn energizes the Electric Switch which provides a ground for power flowing to the Impact relay coil. Through the closed contacts of the Impact relay, power is supplied to energize the Post Landing System Relay. Through the activated contacts of the Post Landing System Relay, power is transmitted to energize the Impact Signal, and the Capsule Stabilization 1 Second Time Delay relays. Through the closed contacts of the Post Landing System relay the self-powered Flashing Recovery Light circuit is completed setting the light in operation. When the Impact Signal relay is energized the Green Main Deploy and Landing Bag Telelights are extinguished and the Red Rescue Aids Telelight is illuminated. At the end of the 1 Second time delay the Capsule Stabilization relay is activated allowing the Main Disconnect and Reserve Disconnect relays to be energized. Through the energized contacts of Main Disconnect relay, the Main Chute Disconnect squibs are fired, releasing the main chute from the capsule. The Reserve Disconnect Relays fire the Reserve Chute Disconnect Squibs releasing the Reserve Chute and energizes the Reserve Deploy relay. The Reserve Deploy relay fires the Reserve Chute Deploy Gun Squibs deploying the Pilot Chute and the Reserve Chute Ejector Bag squibs. The Reserve Chute Ejector Bag squibs activates the gas generator which has a one second delay in ignition time before inflating the ejector bag expelling the Reserve Chute and the dye marker. When the Rescue Aids switch is placed in the "MAN" position, the Rescue Aids Switch Signal, and the Post Landing System Power Drop Hold relays are energized. The energized Rescue Aids Switch Signal relay removes power from the Red Rescue Aids Telelight and illuminates the Green light. The Post-Landing System Power Drop Hold relay energizes the Post-Landing System Power Drop 30 Second Time Delay relay. At the end of the 30 second time delay the Whip Antenna Extend relay is energized firing the Whip Antenna Extend Squibs activating the gas cartridge extending the active element of antenna to its full length. When the Post Landing System Relay is energized on impact, power is removed from a number of components in the circuit. After a 30 second delay the Post Landing System Power Drop relay is energized removing power from the remainder of the components, except the Whip Antenna Extend relay and the Rescue Aids Switch Signal relay which leaves the Green Rescue Aids Telelight illuminated.

9-3. EMERGENCY SEQUENCE DESCRIPTION

The Emergency provisions of the landing system basically consists of manually operated back-up systems initiated by the Astronaut. The appropriate button, pull-ring, and switches are located on the Left Hand Console. The emergency system controls manually initiate deployment of the Drogue, Main and Reserve Chutes, extend the Landing Bag, and initiate rescue aids.

9-4. EMERGENCY SEQUENCE OPERATION (See Figure 9-3)

On descending to 21,000 ft. and Drogue Chute failure is detected by lack of opening shock and by a visual check through the window, depress the Drogue

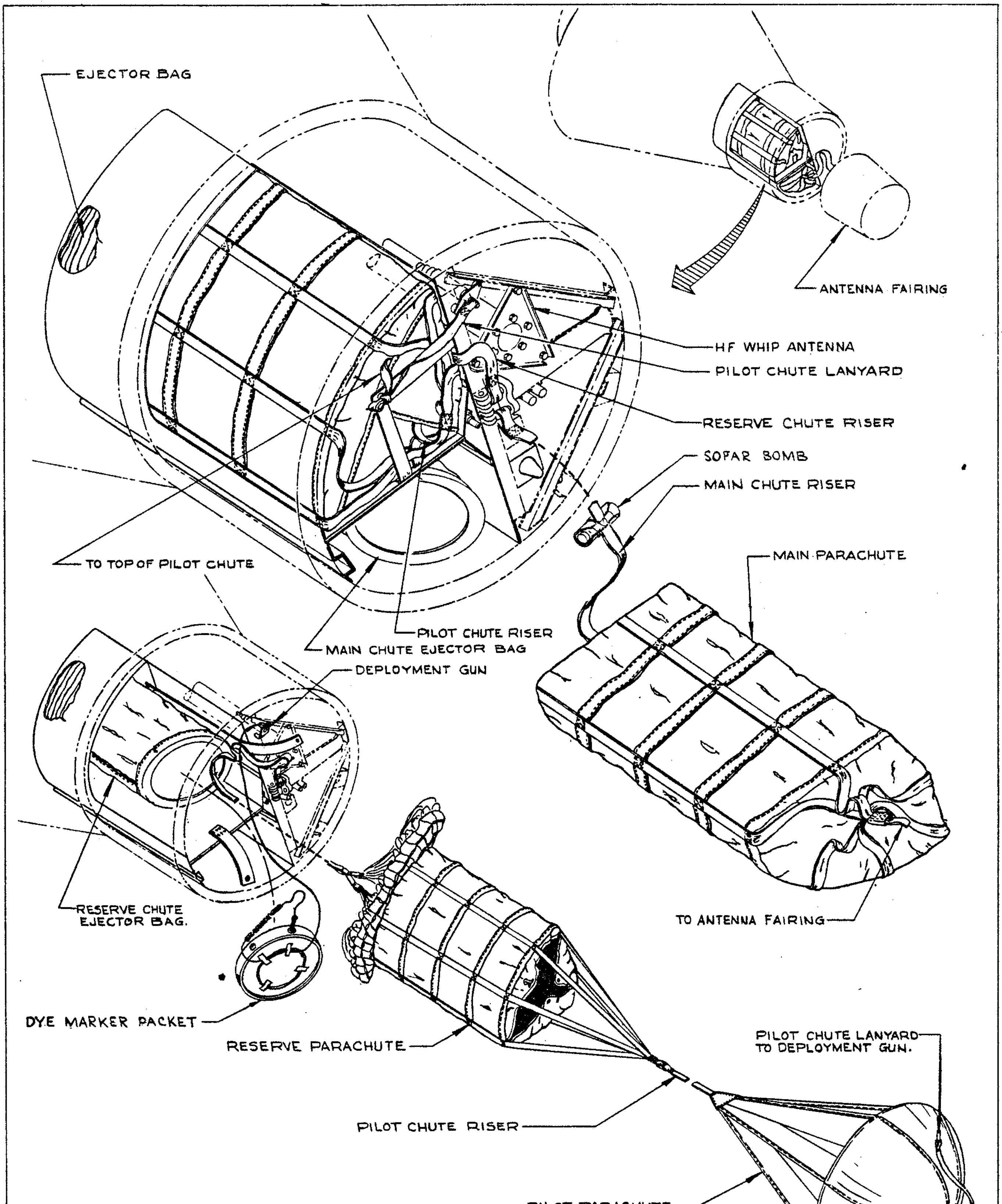


FIGURE 9-2 MAIN AND RESERVE PARACHUTE SYSTEM (SHEET 1 OF 2)

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

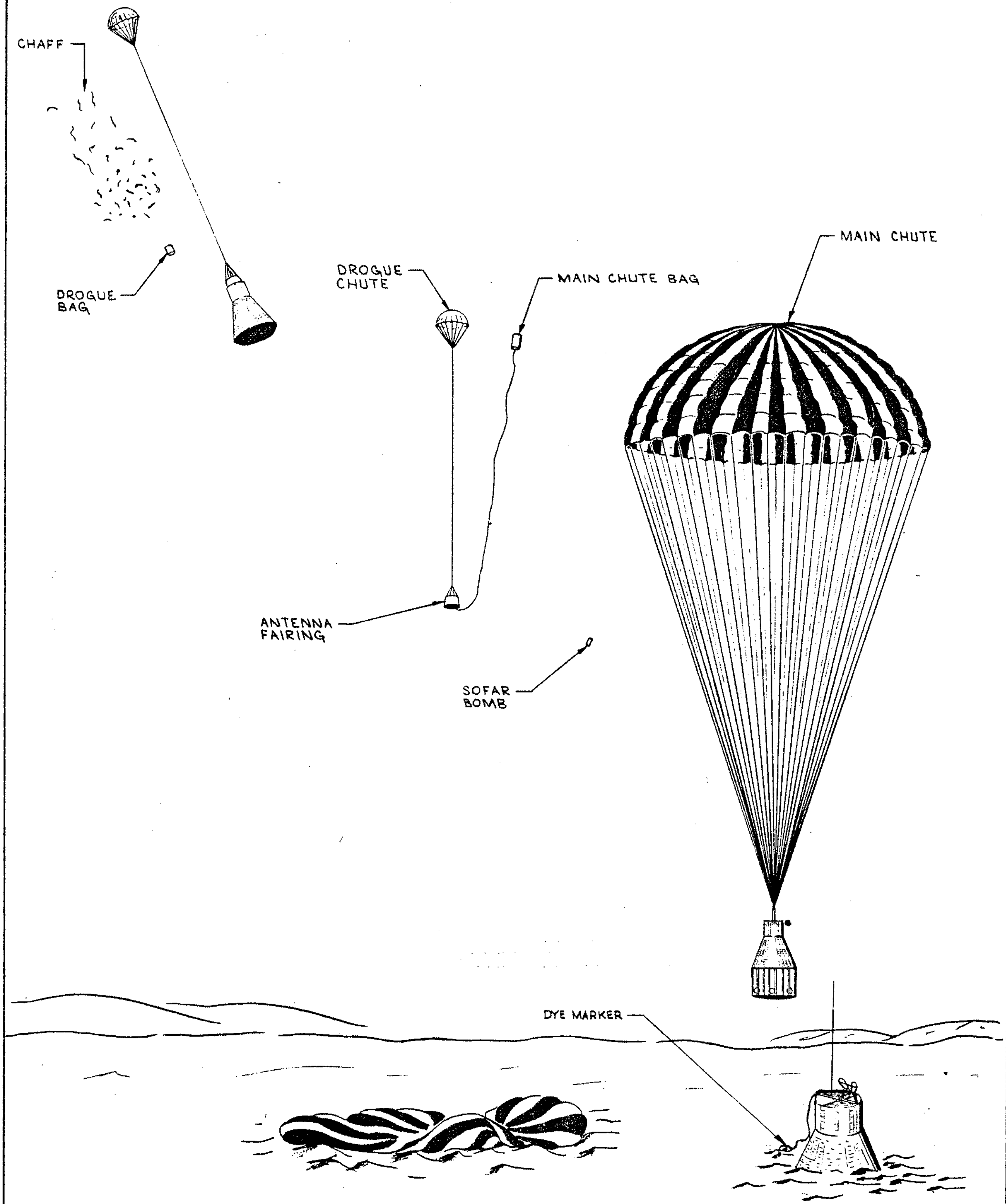


FIGURE 9-2 MAIN AND RESERVE PARACHUTE SYSTEM (SHEET 2 OF 2)

PM45-76B

button. Depressing the button allows the Emergency Drogue Deploy relay to be energized and the Drogue Chute Mortar squibs to be fired deploying the Drogue Chute and dispersing the chaff. If the Green Main Deploy telelight fails to illuminate, failure of the Main Chute deployment may be detected by a lack of opening shock, a visual check and no decrease in rate of descent. Upon determining that the Main Chute has not deployed, operating the Main Deploy Pull Ring energizes the Emergency Main Deploy relay, firing the Antenna Fairing Ejector Squibs, ejecting the Antenna Fairing and deploying the Main Chute through the normal automatic sequence. When the Green Main Deploy telelight is illuminated and the rate of descent is above 32 feet per second, check the chute visually for damage. If the chute is damaged or did not deploy, actuate the Reserve Deploy Pull Ring which energizes the Reserve Deploy relay. Through the energized contacts, power is applied to the Main Chute Disconnect firing the squibs disconnecting the chute from the capsule. At the same time, the Reserve Chute Deploy Gun Squibs are fired deploying the Pilot Chute, and the Reserve Chute Ejector Bag squibs are fired generating a gas after a 1 second delay inflating the ejector bag which aids in deploying the Reserve Chute.

Twelve seconds after the Main Chute is deployed the Green Landing Bag telelight should be illuminated. If the light does not come on, place the Landing Bag switch in the "MAN" position, energizing the Emergency Landing Bag Extend relay, firing the Emergency Landing Bag Valve Squibs, releasing the heat shield and extending the impact landing bag. Ten minutes after impact the Rescue Aids Switch By-Pass relay is energized. When activated, the relay by-passes the Rescue Aids switch and energizes the relays that supply power to fire the Main Chute Disconnect squibs as well as the squibs for the Reserve, Disconnect, Deploy Gun, and the Ejector Bag in the same manner as would be done if the switch was placed in the "MAN" position.

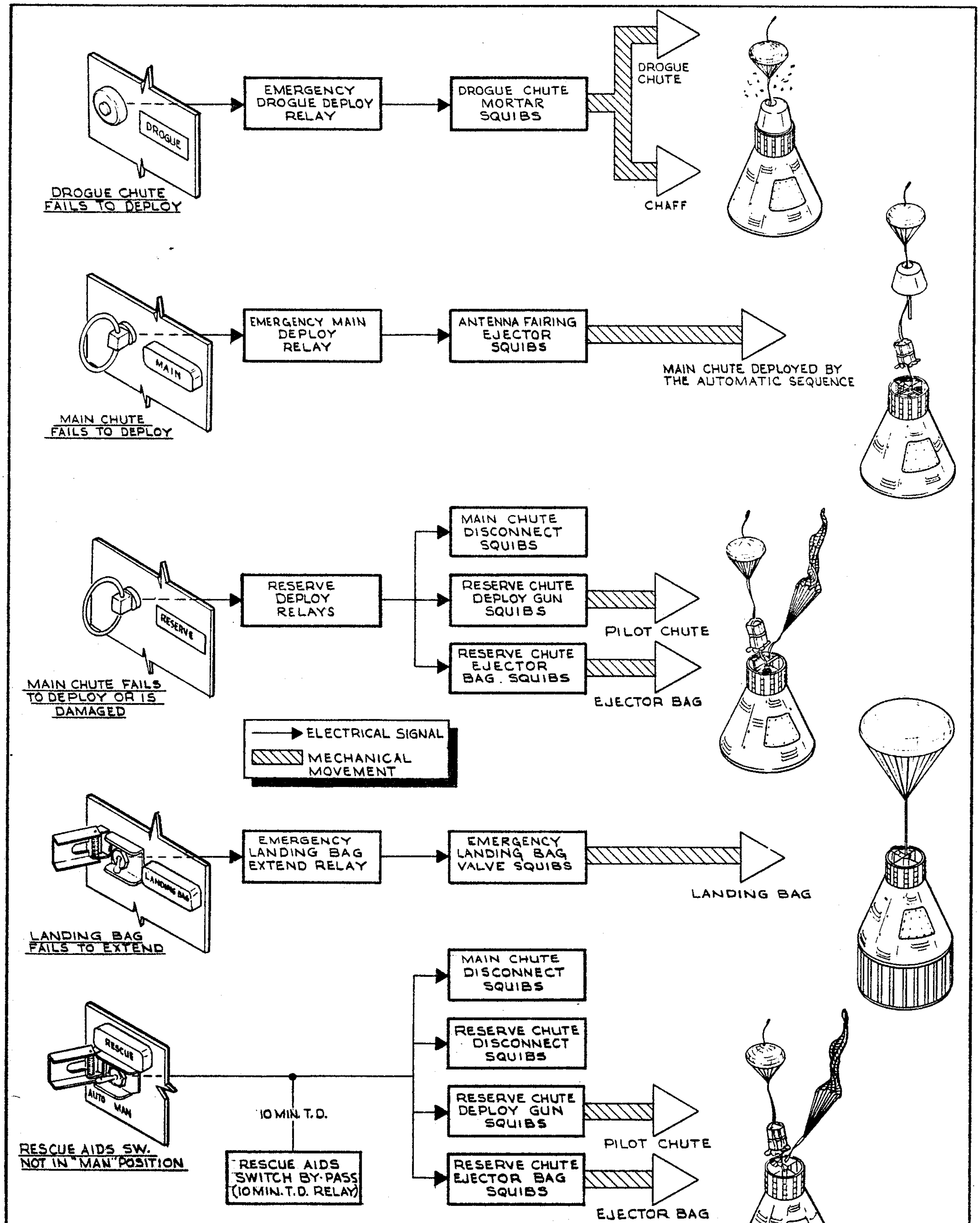


FIGURE 9-3 LANDING AND RECOVERY EMERGENCY SYSTEM BLOCK DIAGRAM

PM45-260A

9-5. SYSTEM COMPONENTS

9-6. DROGUE PARACHUTE

The drogue parachute assembly (See Figure 9-5) consists of a conical ribbon-type drogue canopy with integral riser, drogue deployment bag, drogue mortar, sabot, chaff packet, and drogue mortar cover. The drogue parachute canopy is a conical ribbon parachute having 8 gores of 2-inch wide, 460-lb. tensile strength ribbons and 8 tubular nylon suspension lines of 1,000-lb. tensile strength each. The parachute is constructed to a diameter of 6.85 feet and permanently reefed (restricted) to an effective diameter of 6.0 feet by means of pocket bands. The constructed total porosity is 27.9% and the effective porosity (through reefing) is 36.3%. The 30-ft. long integral riser is made from three layers of 3,000-lb. tensile strength low-elongation hot-stretched Dacron webbing. The drogue parachute stabilizes and decelerates the capsule. The canopy weighs 2.9 lbs. without riser and 5.9 lbs. including the 30-ft. Dacron riser. The drogue parachute deployment bag serves a dual function of (1) protecting the drogue parachute during ejection and (2) providing means for orderly deployment of the drogue parachute. The bag is manufactured of cotton sateen fabric reinforced with nylon webbing and covered at the upper end with a heat insulator of glass cloth. The bag is weighted at the upper end with a 0.5 lb. lead disc which assists in stripping the bag from the canopy at the completion of line and riser stretchout. Inside of the bag are 4 cotton tapes to which the riser is secured during packing in order to provide orderly riser deployment. The mouth of the bag is closed with a light cotton cord.

9-7. DROGUE CHUTE MORTAR AND SABOT

The drogue parachute ejection mortar is a device for positively deploying the drogue parachute with sufficient energy to overcome local pressure gradients and gravitational forces. The drogue parachute is packed in a protective bag

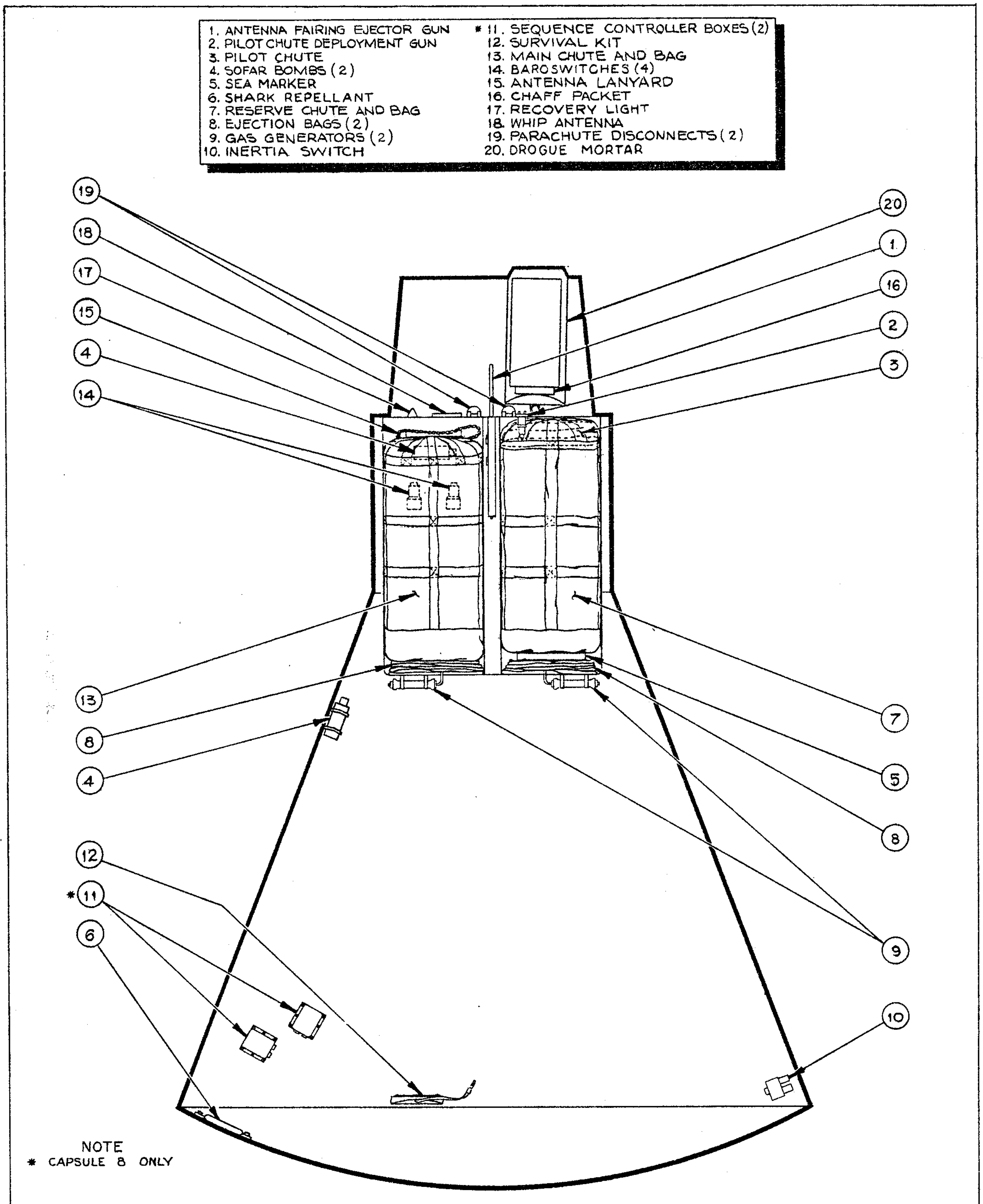


FIGURE 9-4 LANDING AND RECOVERY SYSTEM INSTALLATION

PM45-74C

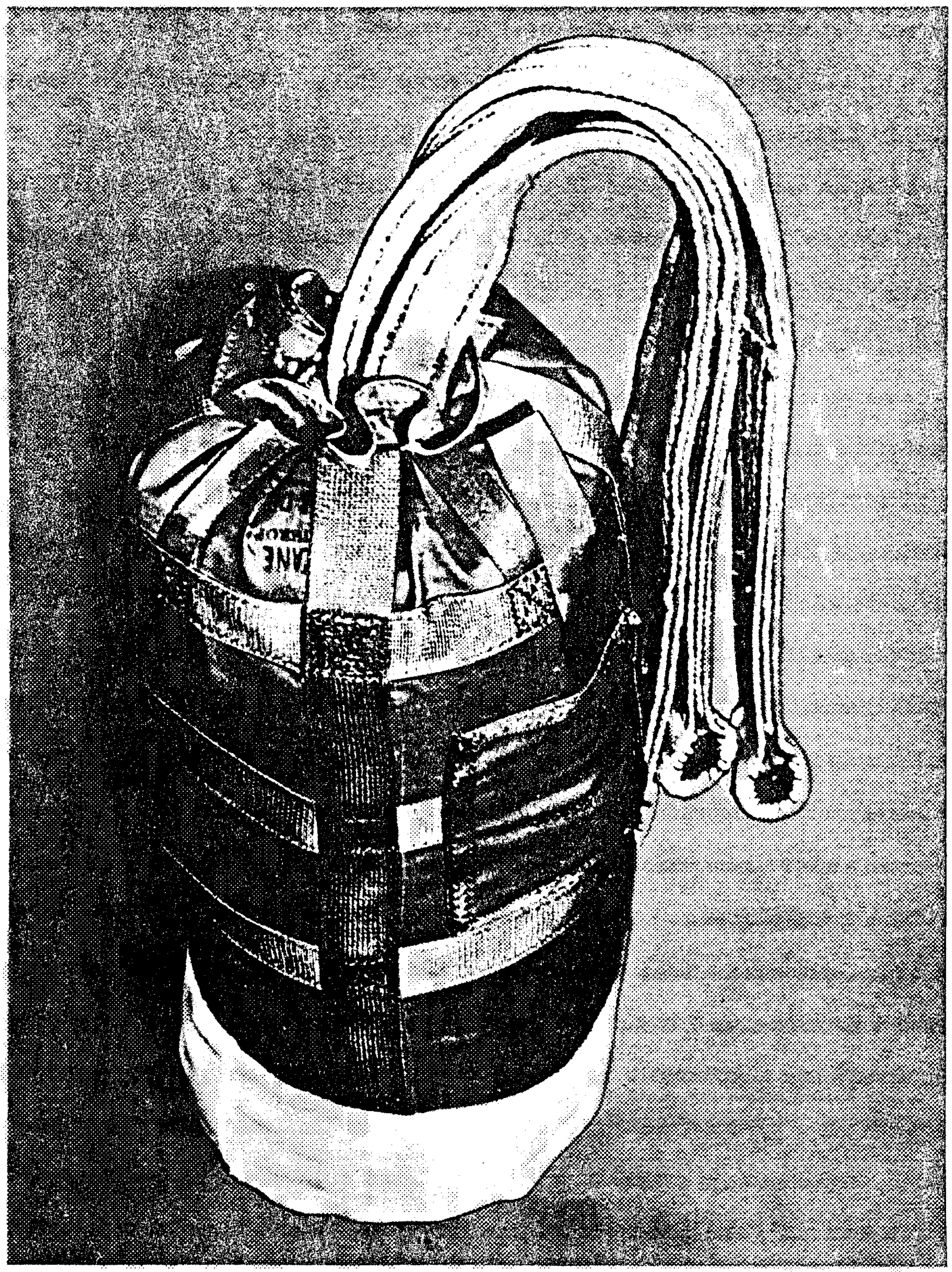
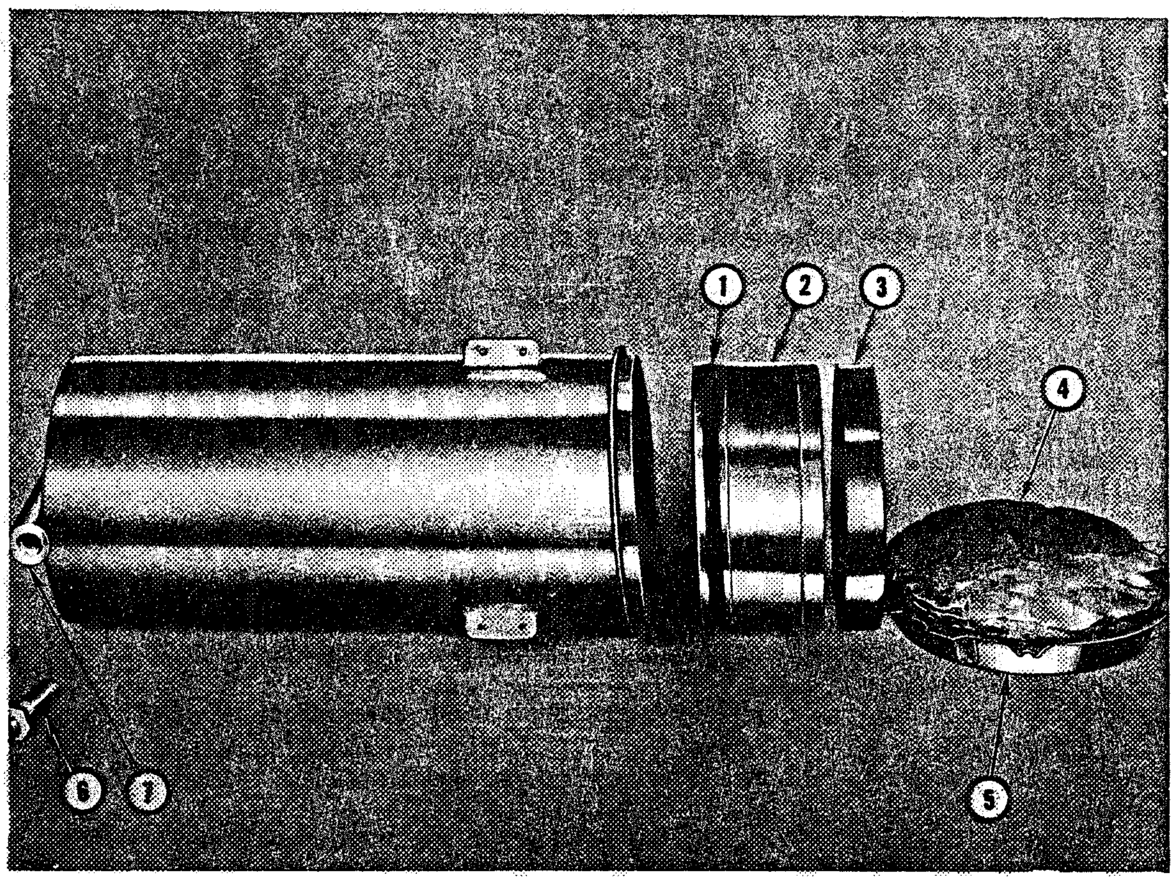


FIGURE 9-5 DROGUE PARACHUTE

and stowed in the mortar tube on top of a lightweight sabot (See Figure 9-6). The sabot functions as a piston to eject the parachute pack, when pressured from below by gases generated from a pyrotechnic charge. The propellant charge is initially fired into a breach chamber of small volume, to produce high pressure which is subsequently vented through a small orifice and into the main chamber at relatively lower pressures. In this manner, reaction loads are kept to a minimum, since the pressure energy is not expended instantaneously. The pressure sealing quality of the sabot is derived from an "O" ring, installed in a groove near the base. Two small holes are located in the "O" ring groove to vent air trapped in the mortar tube underneath the sabot on installation. For proper operation, the "O" ring and the inner wall of the mortar tube, which is always in contact with the "O" ring, are lubricated before installation. The drogue parachute pack is retained in its stowed position within the mortar tube by a thin metal (Rene "41) cover which is attached to the upper surface of the antenna housing. Three cut-out sections, provided in the sides of the cover, permit routing of the steel cable risers into the drogue chute can. The cover is designed to constrain the chute in its compartment against negative decelerations and also to require minimal forces to break loose from its attachments at the time of deployment. Pressure of the chute pack causes the cover to deflect such that attachment tabs pull out from under attaching screw heads through a slotted hole designed for this purpose. The energy required to expel the drogue chute from its compartment is provided from high pressure gases, generated by ignition of a pyrotechnic charge. The cartridge is loaded with 66 grains of powder, contained in a propellant can attached to a steel body which houses the ignition wiring, and terminates in an electrical connector. The ignition circuitry consists of two separate and individual bridges, either of which is capable of igniting the powder charge upon application of the proper current.



1. "O" RING
2. SABOT
3. CHAFF PACKAGE
4. INSULATION
5. COVER
6. CARTRIDGE
7. CHAMBER

FIGURE 9-6 DROGUE CHUTE MORTAR ASSEMBLY

9-8. CHAFF PACKET

The chaff packet is a locating aid which performs its function by distributing fine divided metal foil having radar reflecting capability. The foil strips act as miniature antennae and are capable of providing an average echo area of 600 square feet, covering the S-, L- and C-band radar frequencies. The package is ejected on deployment of the drogue parachute. The chaff is packed in a cardboard package of rectangular shape with dimensions approximately 1 x 3 x 5 inches. When jettisoned into the airstream, the package spills open and disperses its contents.

9-9. MAIN PARACHUTE

The main parachute assembly consists of: Main parachute canopy, riser, deployment bag, and parachute disconnect. The main parachute canopy is a 63 foot nominal diameter ringsail type. The ringsail parachute is a slotted canopy similar in design to the ringslot parachute. The parachute is fabricated from 2.25- and 1.1-ounce per square yard nylon parachute cloth into 48 gores with 48 suspension lines of 550-pound tensile strength. The main parachute is packed in a deployment bag which provides a low snatch force and orderly deployment (See Figure 9-7). The bag is manufactured from cotton sateen fabric, reinforced with nylon webbing and covered at the upper end with Thermoflex and glass cloth insulation. Inside the bag, midway along its length, is a pair of transverse locking flaps. Their function is to separate the canopy fabric from possible entanglement with the lines and to cause full time stretch-out before canopy deployment.

9-10. PARACHUTE DISCONNECT

Both main and reserve parachutes are attached to the capsule by a device designed to sustain the parachute loads during descent and to disconnect the parachute on ground impact (See Figure 9-8). The disconnect function is necessary to prevent capsule upset or damage by dragging in surface winds after touchdown. The assembly consists of 5 separate details installed in a mounting structure which is an integral part of the capsule. The parachute riser is looped around the arm which transmits the load to the structure through the piston. The shear pin restrains the piston from any motion tending to displace it. On ground impact, an electrical impulse from the inertia switch reaches the squib cartridge causing it to fire. The gas pressure, thus generated, forces the piston forward into the arm recess, cutting the shear pin in the process. Full displacement of the piston removes parachute load transmission to structure, allowing the arm to rotate around the pivot pin. The loop of the parachute riser slips off the arm and the disconnect function is complete. The lead buffer serves to absorb energy of moving piston and prevents rebound of the piston back into the locked position.

9-11. RESERVE PARACHUTE

The reserve parachute assembly consists of: The pilot chute deployment gun and lanyard, pilot parachute, reserve parachute canopy, reserve parachute deployment bag, and reserve parachute disconnect. The reserve parachute deployment bag is similar to the main parachute deployment bag with the addition of flaps at the upper end of the bag to contain the packed pilot chute. The reserve parachute disconnect is identical to that used to disconnect the main parachute. The reserve parachute canopy is identical to the main parachute canopy.

9-12. PILOT PARACHUTE

The pilot parachute is a flat, circular type, 72 inches in diameter with a 30 ft. bridle. It is manufactured of 3.5-ounce per square yard fabric in the canopy and 2.25-ounce fabric in the vanes.

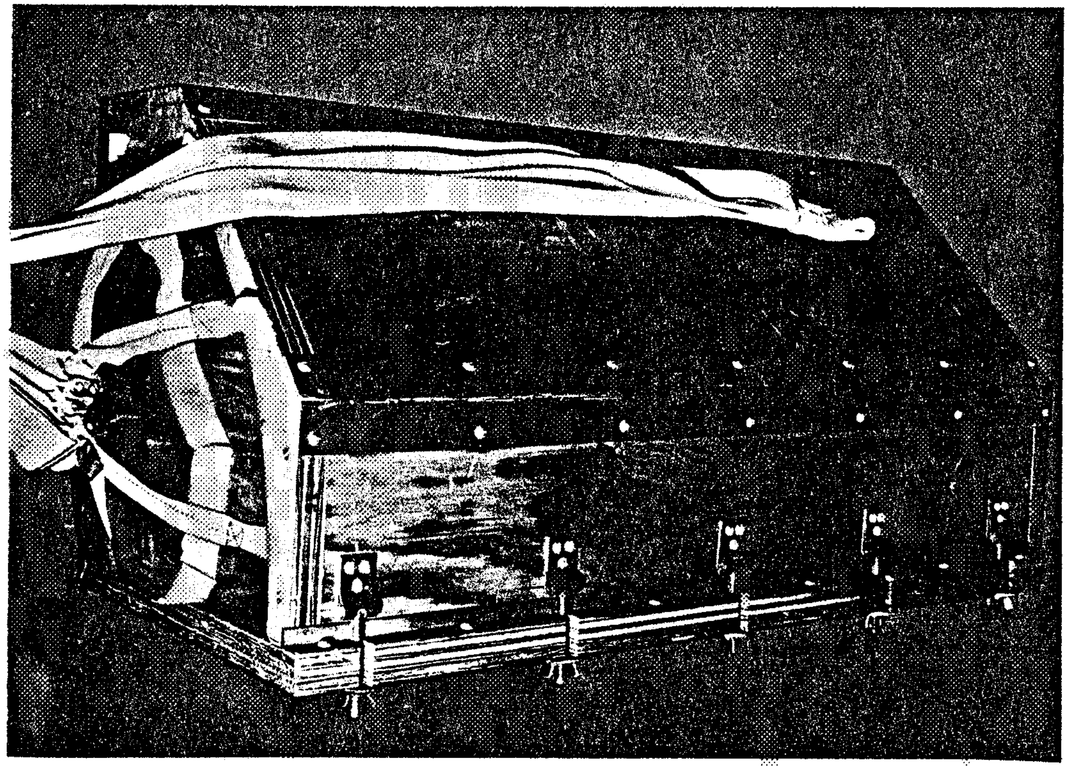
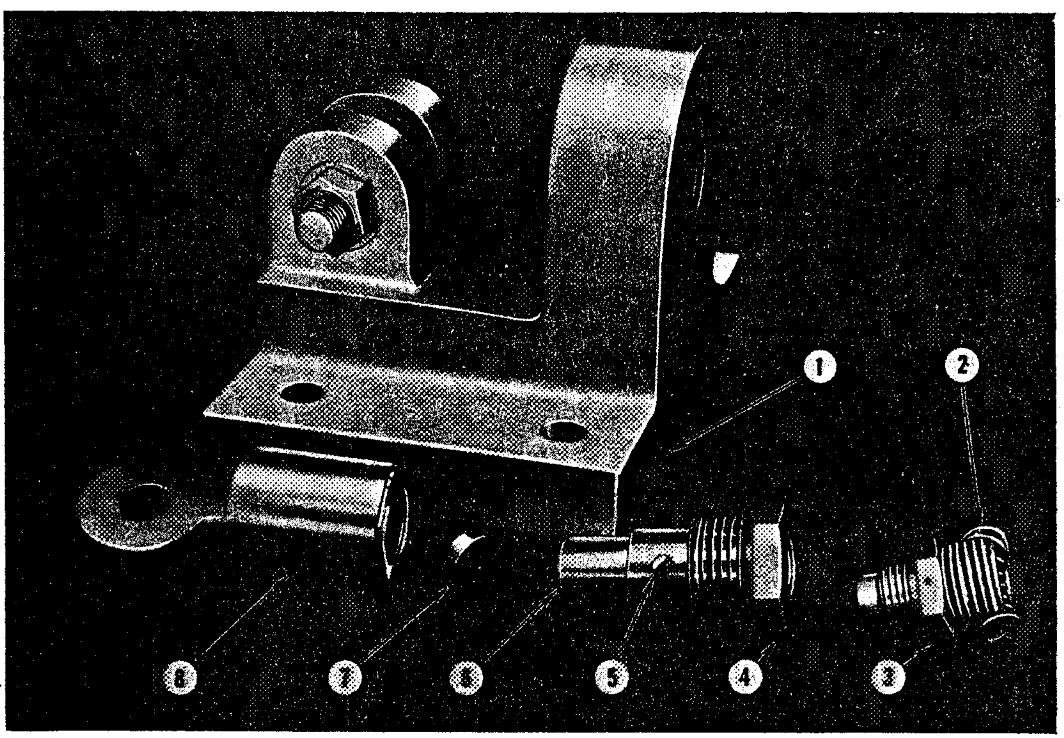


FIGURE 9-7 MAIN PARACHUTE AND PACKING BOX



1. STRUCTURE	5. SHEAR PIN
2. SHORTING WIRE	6. PISTON
3. SQUIB CARTRIDGE	7. LEAD BUFFER
4. BUSHING	8. ARM

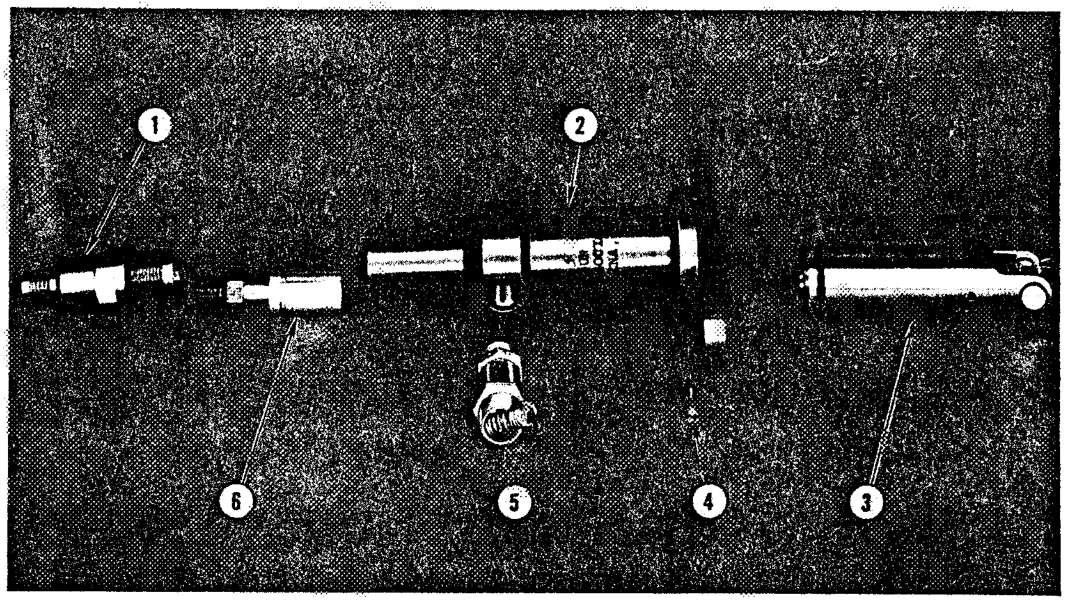
FIGURE 9-8 MAIN AND RESERVE CHUTE DISCONNECT

9-13. PILOT CHUTE DEPLOYMENT GUN

The pilot chute deployment gun (See Figure 9-9) initiates the first step in the sequence of reserve parachute deployment. Either gas pressure or an electrical impulse will cause the gun to fire, thus expelling a 12-ounce projectile to which is attached the reserve parachute pilot chute. The pilot chute inflates and in turn pulls out the reserve landing chute, completing the sequence. Whether fired electrically or pneumatically, a one-second time delay is provided between receipt of the impulse and detonation of the main charge. This delay permits the main parachute (if deployed and damaged) to separate from the capsule, to avoid entanglement with the reserve parachute to be deployed. The gun is basically a tubular body which contains the main firing cartridge and the projectile assembly. The projectile assembly is held in place by a pin which is sheared when the projectile is expelled. The main cartridge, which generates the gas pressure to eject the projectile, is fired as follows: (1) Gas pressure, through the gas firing mechanism (supplied when RESERVE-PULL-RING is operated), drives a firing pin into the primer cap at the base of the main cartridge, initiating a time delay train, causing a subsequent detonation of the charge. A minimum of 750 psi gas pressure is required for pneumatic operation. (2) An electric impulse is received at the time delay igniter installed through the side of the gun. After a one-second delay, the igniter fires through the wall of the main cartridge and detonates it instantaneously. Firing characteristics of the igniter cartridge are as follows: All Fire Current 2.5 amps per bridge, All Fail Current 0.5 amps per bridge. The ignition circuit consists of two individual bridges terminating in a 4-pin receptacle. Muzzle velocity of the projectile is 250-300 ft/sec.

9-14. PARACHUTE EJECTOR BAGS

The ejector bags are inflatable air cells made of lightweight rubberized



1. FIRING MECHANISM	4. SHEAR PIN
2. BODY	5. ELECTRIC CARTRIDGE
3. PROJECTILE	6. MAIN CARTRIDGE

FIGURE 9-9 PILOT CHUTE DEPLOYMENT GUN

FIGURE 9-10 PARACHUTE EJECTOR BAG

nylon fabric (See Figure 9-10). The design inflated shape is that of a cylinder, 11 inches in diameter and approximately 35 inches in height. The upper end of the bag is slanted at full inflation to promote jettison of the parachute pack overboard on landing impact.

9-15. PARACHUTE EJECTOR GAS GENERATOR

This is a device to provide a rapid and sufficient volume of gas to inflate the main and reserve parachute ejector bags (See Figure 9-11). The reserve parachute gas generator is similar to that used for the main parachute except the additional feature of one second delay in ignition time. The generator functions to produce gas by the relatively slow burning of a solid powder propellant in the main chamber. The gas is directed from the main chamber into the ejector bags through a 3/8 in. diameter stainless steel tube. The tube serves also as a heat exchanger to reduce temperatures to within tolerable values prior to entry into the ejector bag. The generator body is equipped with lugs for mounting to the parachute container with four bolts. Ignition circuit characteristics are as follows: All Fire Current 2.5 amps, All Fail Current 0.5 amps.

9-16. SOFAR BOMBS

A post-landing recovery aid. SOFAR is an abbreviated form for "sound fixing and ranging" (See Figure 9-12). This component performs its function when it detonates by hydrostatic pressure at a predetermined water depth. Shock waves from the explosion are received by sound detection devices aboard picket ships or shore bases and a position fix on the capsule is thus made. The maximum range of the Mercury SOFAR bombs is 3000 miles. Two bombs are carried aboard the capsule; one set to detonate at 4000 feet depth and one set for 3500 feet. The bomb weighs approximately 2 pounds. One 3500 foot bomb is tossed overboard at main chute deployment. The second SOFAR bomb remains with the capsule and only serves to notify the search party that the capsule is sufficiently below the water's surface to render it non-recoverable. (See Figure 9-13 for Operation.)

CAUTION

The bombs are relatively safe to handle, but it should be remembered that they are high explosive devices and hence common sense precautions should be practiced.

9-17. DYE MARKER PACKET

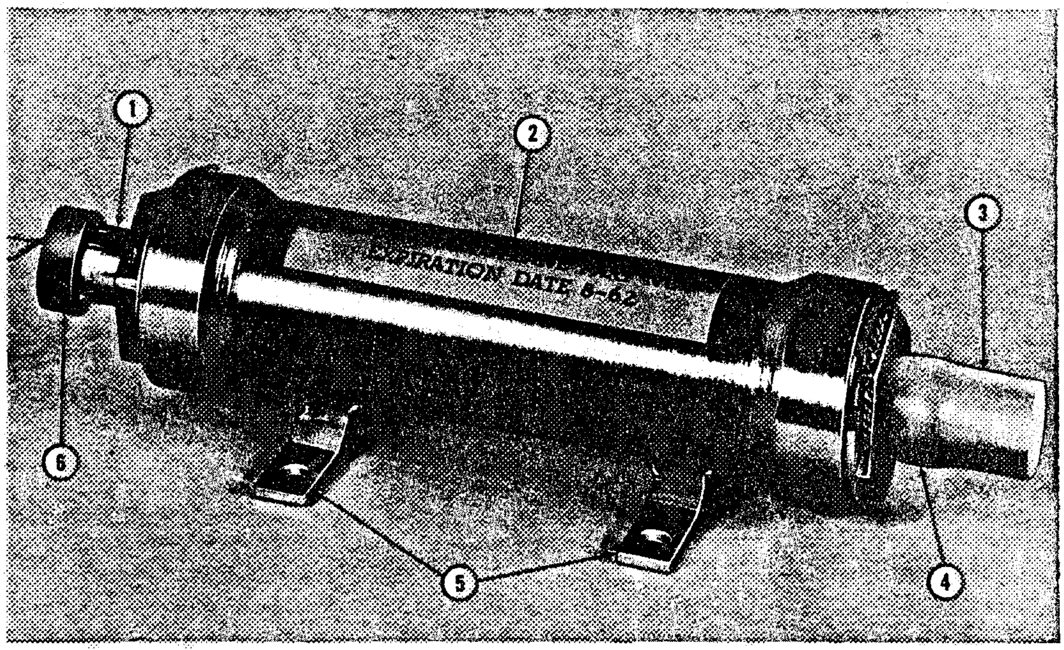
The dye marker packet (See Figure 9-14) is a post landing recovery aid which performs its function by dissolving in water, thus producing a highly visible yellow green patch. Approximately 1 pound of fluorescein dye is packed into a soluble plastic bag, which in turn is packed into an outer aluminum container. The entire packet assembly is ejected overboard, at the time of reserve chute ejection. The fluorescein dye forms a spot on the ocean surface which is visible from an airplane 10,000 feet high at a distance of 10 miles on a clear day.

CAUTION

The dye marker package should be stored in a dry place and not be exposed to water in any way.

9-18. RECOVERY LIGHT

To aid in the visual location of the capsule after landing, a flashing light is installed in the recovery compartment. The intensity of the light is such that it will be visible in normal darkness for 40 nautical miles and up to an altitude of 12,000 feet. The flashing rate is approximately 15 flashes per minute. Powered by self contained, dry cell batteries, the light's circuit will



1. ELECTRICAL CONNECTOR	4. TUBE FITTING
2. MAIN CHAMBER	5. ATTACHMENT LUGS
3. PROTECTIVE CAP	6. SHORTING PLUG

FIGURE 9-11 MAIN AND RESERVE CHUTE GAS GENERATOR

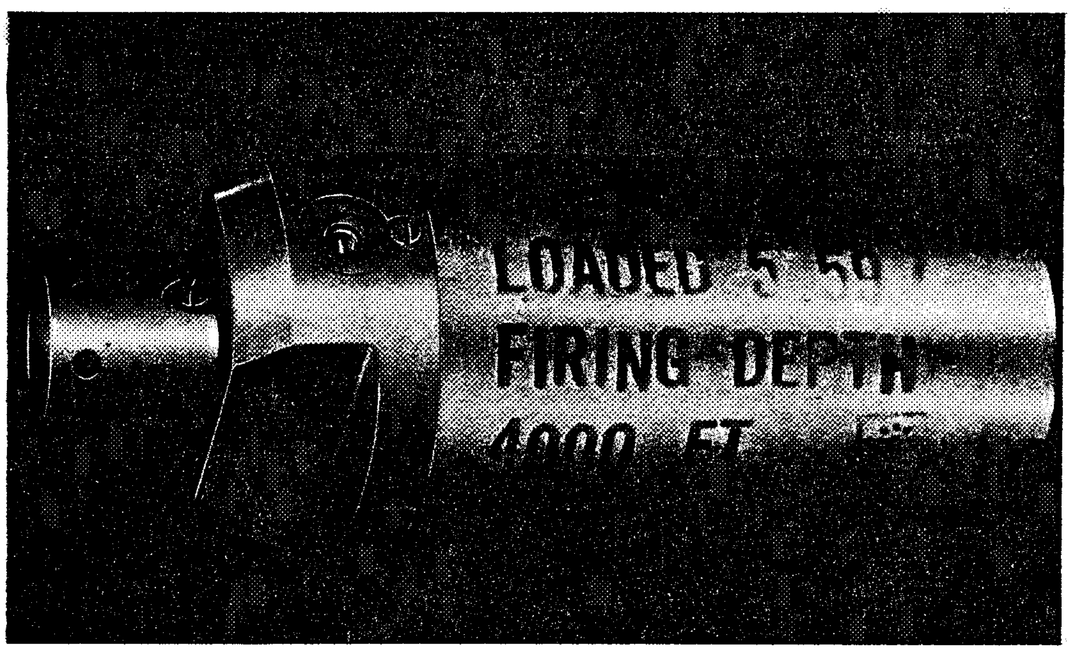
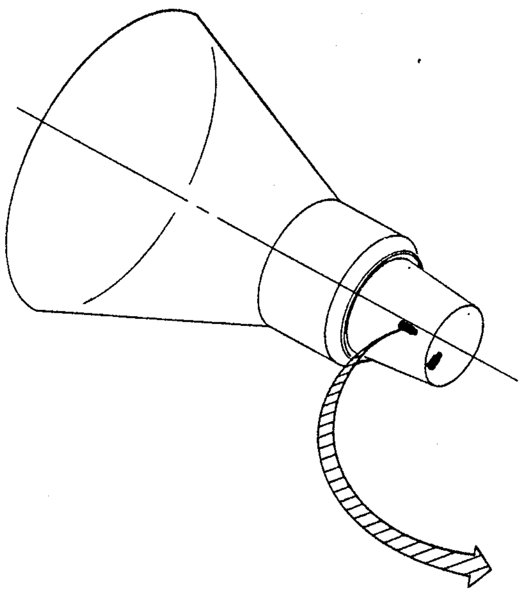
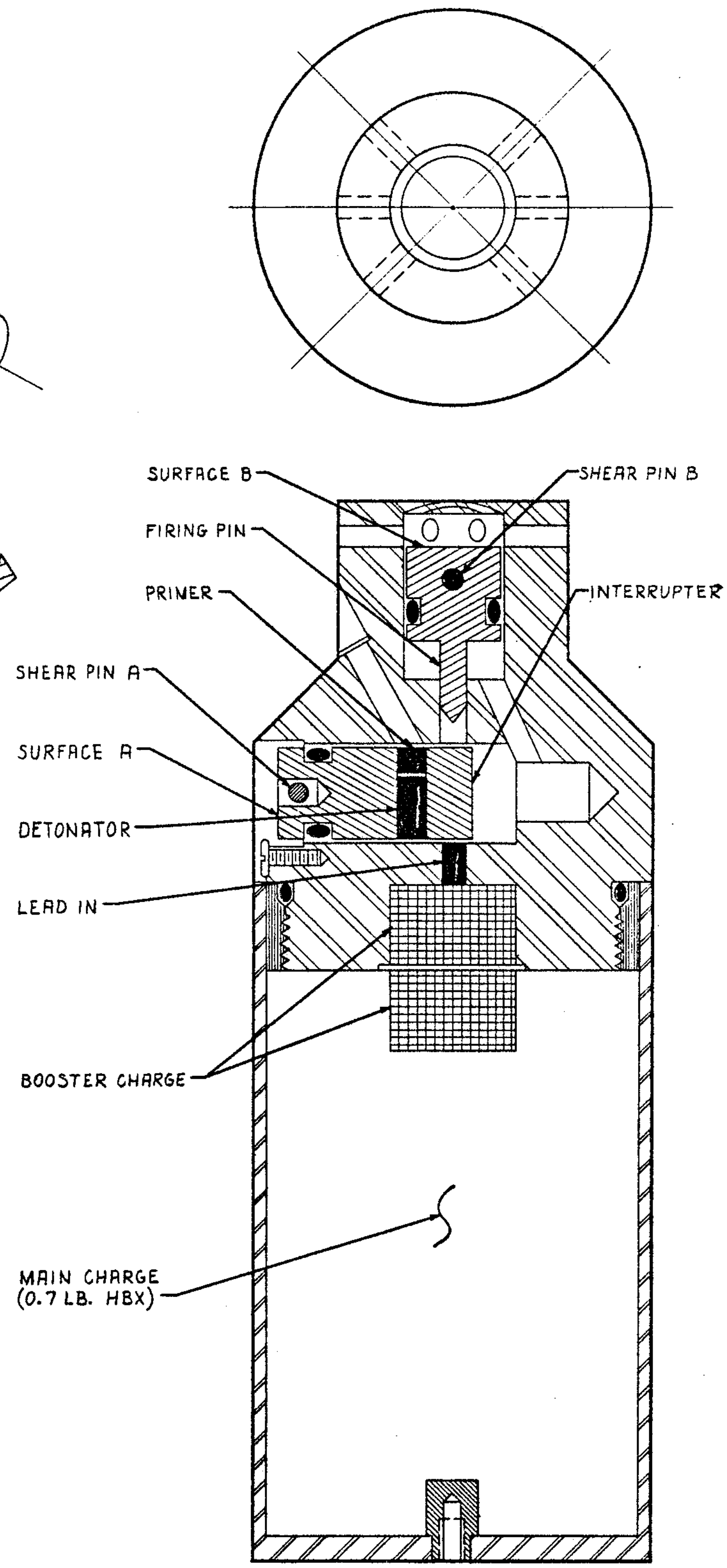


FIGURE 9-12 SOFAR BOMB





OPERATION

DETONATION OF THE MAIN CHARGE IS ACCOMPLISHED IN TWO STAGES:

A. WATER PRESSURE ON SURFACE "A" CREATES A FORCE SUFFICIENT TO BREAK SHEAR PIN "A" PERMITTING THE INTERRUPTER BLOCK TO MOVE UPWARD AGAINST THE STOPPING SHOULDER. WHEN IN THIS POSITION, THE PRIMER CHARGE IS IN LINE WITH THE FIRING PIN.

B. WATER PRESSURE ON SURFACE "B" CREATES FORCE TO BREAK SHEAR PIN "B" AND DRIVE THE FIRING PIN INTO THE PRIMER CHARGE. THE PRIMER CHARGE BLASTS INTO THE BOOSTER CHARGE VIA THE LEAD IN ORIFICE, AND THE BOOSTER CHARGE CAUSES THE MAIN CHARGE TO DETONATE. STRENGTH OF SHEAR PIN "B" IS PREDETERMINED FOR DESIRED DETONATION DEPTH. STRENGTH OF SHEAR PIN "A" IS SUCH THAT IT WILL SHEAR AT A DEPTH OF APPROXIMATELY ONE HALF THE DEPTH REQUIRED TO SHEAR PIN "B".

FIGURE 9-13 SOFAR BOMB SCHEMATIC

PM45-166

be closed through an energized contact of the Post Landing System Relay which is activated by the closing of the Inertia switch on impact and energizing the Impact relay. The light will operate for approximately 28 hours.

9-19. WHIP ANTENNA

To provide operation of the HF voice receiver-transmitter and HF recovery beacon, a Whip Antenna is used. The active element is stowed in a collapsed condition in the recovery compartment and when extended is approximately 16 feet long. The antenna is extended by a gas cartridge which is activated when the Post-Landing System Power Drop 30 Second Time Delay relay energizes the Whip Antenna Extend relay. When it is extending a galling action takes place between the segments of the active element holding it rigid in the extended position.

9-20. BAROSWITCHES

There are two pair of Baroswitches used in the recovery system (See Figure 9-16). In these switches an over-center spring is included in the design to minimize chatter during vibration and shock and to prevent contact oscillation. One pair of switches is set to close at 21,000 feet and the other is set to close at 10,600 + 750 feet. The switches are located in the recovery compartment where they are connected to a plenum chamber. The plenum chamber collects ambient air pressure through four static pressure ports equally located around the recovery compartments outer surface.

9-21. INERTIA SWITCH

The inertia switch is essentially a spring device actuated by mass (See Figure 9-17). A landing shock of 7.5 plus or minus 1.13g's minimum will produce momentary closing of two electrical contacts, thus completing an electrical circuit. This switch is used in conjunction with a latching relay which receives

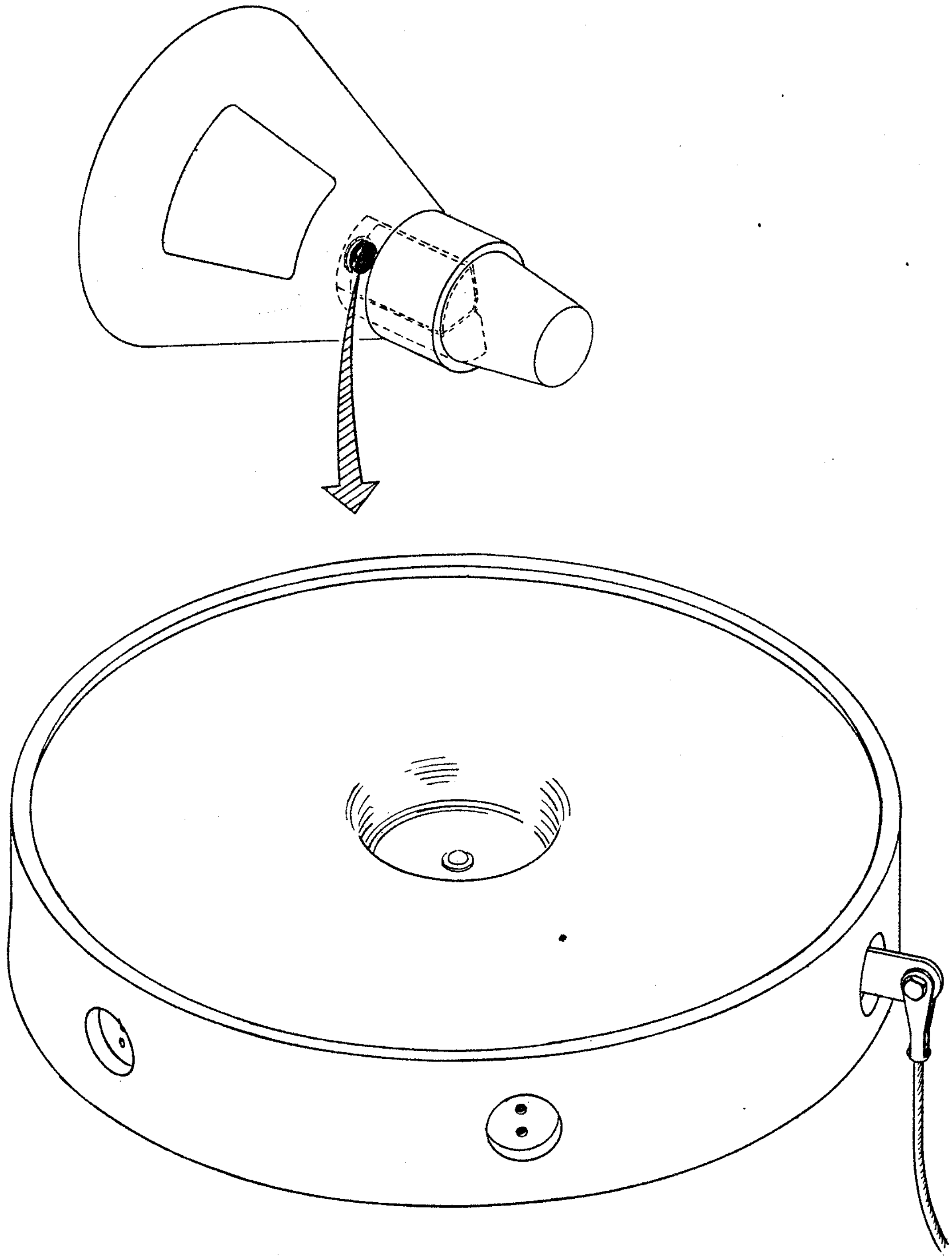


FIGURE 9-14 DYE MARKER PACKET

PM45-170A

an electrical pulse and, by latching into a latched position, provides continuous electrical continuity. The inertia switches used consist of four separate snap-action switches and two separate masses, all housed in a common case.

9-22. TEST CONFIGURATION CAPSULES

9-23. TEST CONFIGURATION CAPSULE NO. 8

The normal mission sequence and escape sequence for Capsule No. 8 differs from the Specification Compliance Capsule as described in the following paragraphs.

The reserve parachute is replaced with a flotation pack. This flotation pack will be attached to the main parachute in such a manner as to act as a buoy after main chute disconnect to enable recovery of the main parachute. Three dye marker packets are installed in the antenna fairing, which remains attached to the main chute. These markers will assist in locating the floating main chute and antenna fairing.

9-24. Operation

The capsule's landing system is armed by 28 volt d-c power at time of escape tower separation. Both isolated and main battery power circuits are applied through the de-energized impact relay No. 1 located in the No. 1 recovery relay box, through the de-energized No. 2 and No. 3 orbit attitude relays and the de-energized No. 2 and No. 3 tower separation sensor relays located in the No. 3 launch and orbit relay box, to the two 3 second time delay relays located in sequence controllers, units A and B. After the 3 second time delay both relays are energized and complete two separate circuits to the four baroswitches. The Baroswitch contacts will be open due to altitude being in excess of 21,000 ft., and therefore the power circuit will stop at the open contacts of the switches. Upon re-entry from orbit, at an altitude of 21,000 feet the two 21,000 ft. baroswitches are actuated and the drogue parachute is deployed and a chaff package

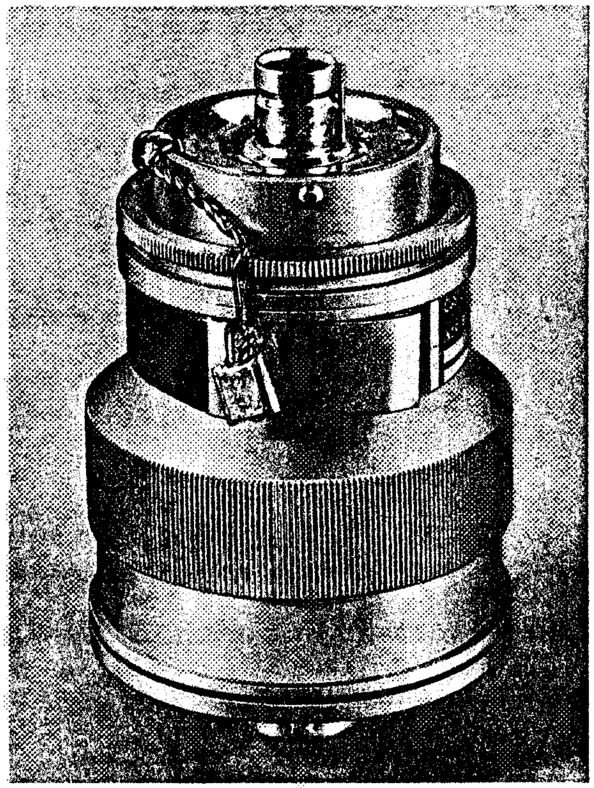


FIGURE 9-15 BAROSWITCH

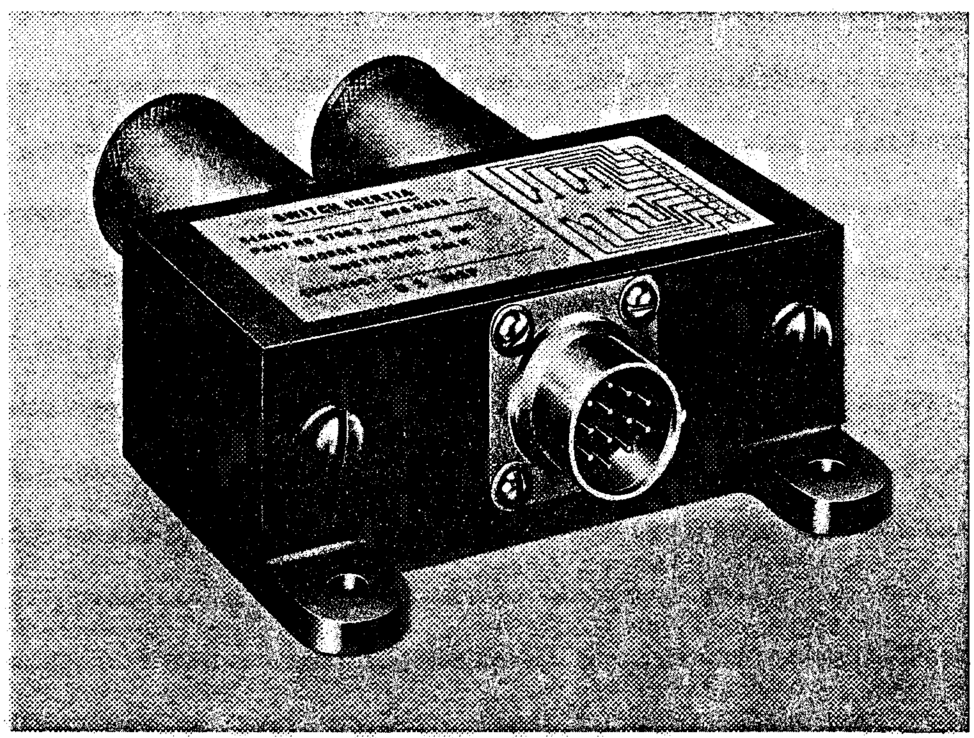
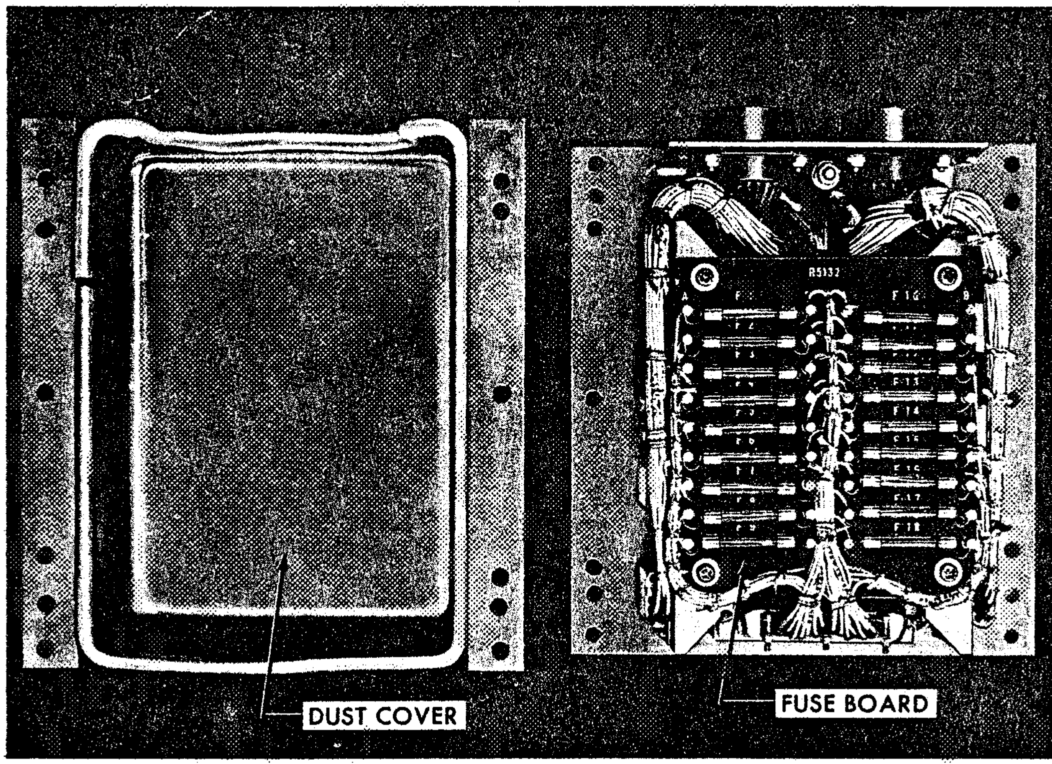


FIGURE 9-16 INERTIA SWITCH

is ejected. The drogue chute stabilizes and decelerates the capsule; the chaff package disperses finely cut metal foil. As capsule descent passes through the 10,000 ft. level, the two remaining baroswitches will close causing dual circuits through the small pressure bulkhead disconnects to the system A and B sequence controllers. These two circuits energize a main squib short (auto) relay within each controller unit, resulting in the removal of ground circuits for all four squibs of the antenna fairing ejector. At the same time, and by the same power that energized the relays, power is applied to the pre-grounded circuits of the four antenna fairing squibs through the de-energized main over-ride relay. As the circuits are completed to the four squibs, two other branch circuits are applied to the two antenna fairing separation sensor limit switches. The firing of the four squibs causes the antenna housing to separate from the capsule. A lanyard, connected from the antenna housing to the main chute, extracts the main chute from the main chute compartment. The separation of the housing from the capsule allows two antenna fairing separation sensor limit switches to spring to their actuated position. Through these two double pole, actuated limit switches, three signals are returned, two entering the system A and B sequence controllers where they start two 12 second time delay relays, and the third signal entering the No. 1 recovery relay box where it energizes the four antenna fairing separation relays. Through the energized No. 3 antenna fairing separation relay, in the No. 1 recovery relay box, a 28 V signal is completed to the Main Deploy telelight, illuminating the light Green. Power is also applied through the contacts of the No. 3 antenna fairing separation relay to fire the two Main Chute Ejector Bag Squibs. The firing of the squibs allow the eject bag to be gas inflated and therefore, simultaneously eject the main chute as the chute is being extracted by the antenna fairing lanyard. At the run-out of the two twelve second time delay relays, the relay coils are energized and arming the contacts of the inertia switch. At the time of landing the inertia switch will sense the impact and complete two 28 V signals to the two inertia switch slave latching relays located in system A and B sequence controllers. These two relays when energized will in turn energize the two reserve and main jettison relays in their respective sequence controller boxes. The energized reserve and main jettison relays will fire the two squibs of the main chute disconnect thereby releasing the main chute from the capsule. The reserve chute disconnect will not be fired at this time. The main battery power circuit that energized the system A reserve and main jettison relays through the inertia switch slave relay is now continued out of the system A sequence controller to the No. 1 recovery relay box. This is the first time in the overall sequence that a dual redundant circuit is not provided. This 28 V circuit to the No. 1 recovery relay box passes through this relay box to the No. 2 recovery relay box where it again passes through the de-energized air shutoff relay and out of the No. 2 recovery relay box after branching into two circuits. One circuit is applied directly to the Astronaut's rescue aids switch and the other is returned to the No. 1 recovery relay box where it energizes the four impact relays. Through the energized No. 1 impact relay the self-powered recovery flashing light circuit is closed starting the flashing light to operate. Through this same relay, power is removed from the two 3 second time delay relays and the Main Deploy telelight will go out. With the rescue aids switch closed, a 28 V circuit is completed to the No. 1 recovery relay box where it energizes the rescue aid relay. Through the energized relay the Torus Bag Deflate 5 second time delay relay is energized and starts timing. Power circuits to the two squibs of the reserve chute disconnect, and also to the two squibs of the reserve chute deploy gun and the two squibs of the reserve chute eject bag are completed. Simultaneously, the reserve chute is disconnected, the reserve pilot chute is deployed and the eject bag be-



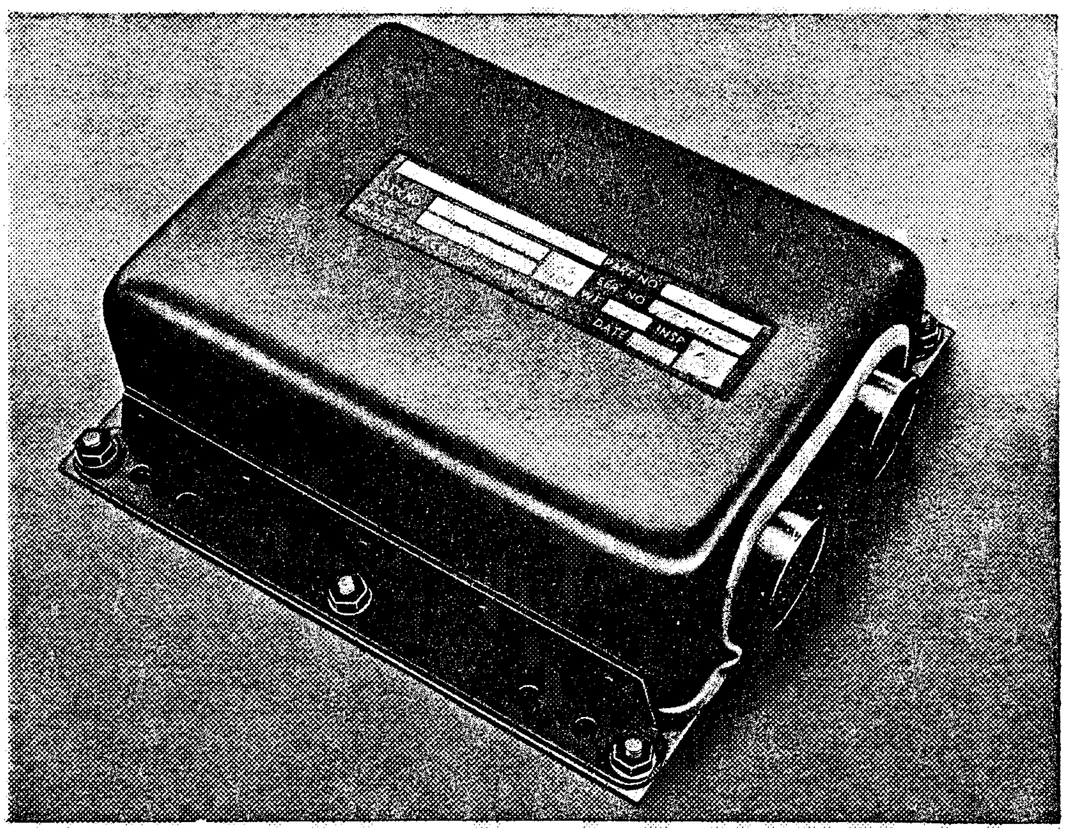


FIGURE 9-17 SEQUENCE CONTROLLER SYSTEM A AND B

neath the reserve chute is inflated forcing the chute out. After the runout of Torus Bag Deflate 5 Second Time Delay relay the Whip Antenna Extend relay is energized allowing power to flow to the whip antenna squib. The energized Gas Cartridge extends the active element its full length.

9-25. Emergency Sequence

9-26. Description

The landing and recovery manually operated emergency system is the same as the Specification Compliance Capsule but Capsule No. 8 is unmanned.

9-27. Components

9-28. Sequence Controller Assembly

There are two landing and recovery system sequence controllers located within the pressurized section of the capsule (See Figure 9-18). These sequence controllers in conjunction with three relay boxes accomplish all the system sequencing and provide other capsule systems with initial commands. The sequence controller assembly contains the relays, fuses, and timers needed to accomplish deployment of the chutes in proper sequence.

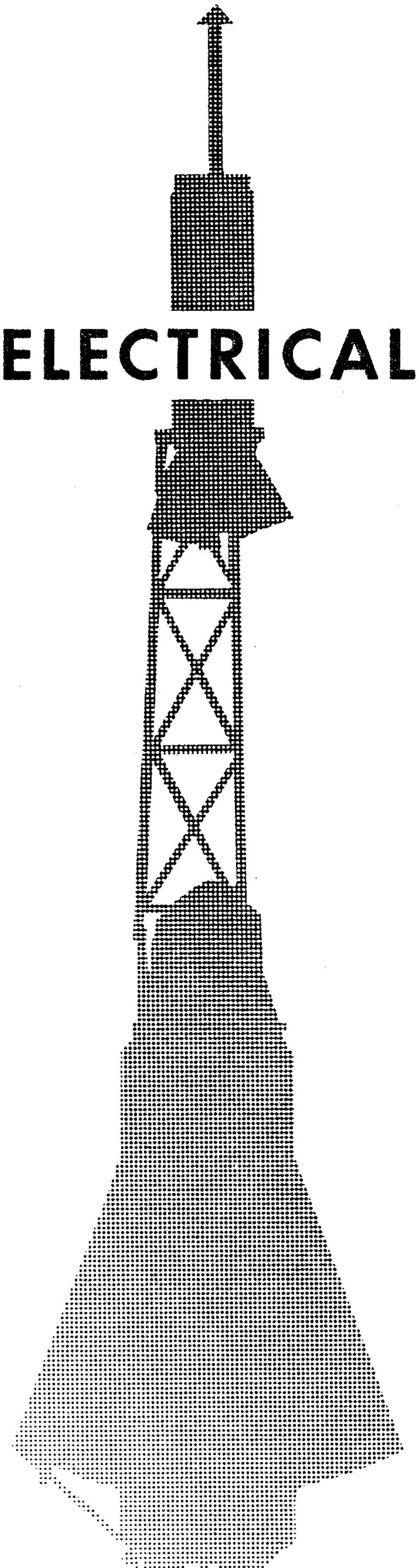
9-29. TEST CONFIGURATION CAPSULES NO. 9 AND 13

Basically the same as Specification Compliance Capsule.

9-30. TEST CONFIGURATION CAPSULES NO. 10 AND 16

Same as Specification Compliance Capsule.

SECTION X



ELECTRICAL POWER AND INTERIOR LIGHTING SYSTEMS

TABLE OF CONTENTS

CONFIDENTIAL

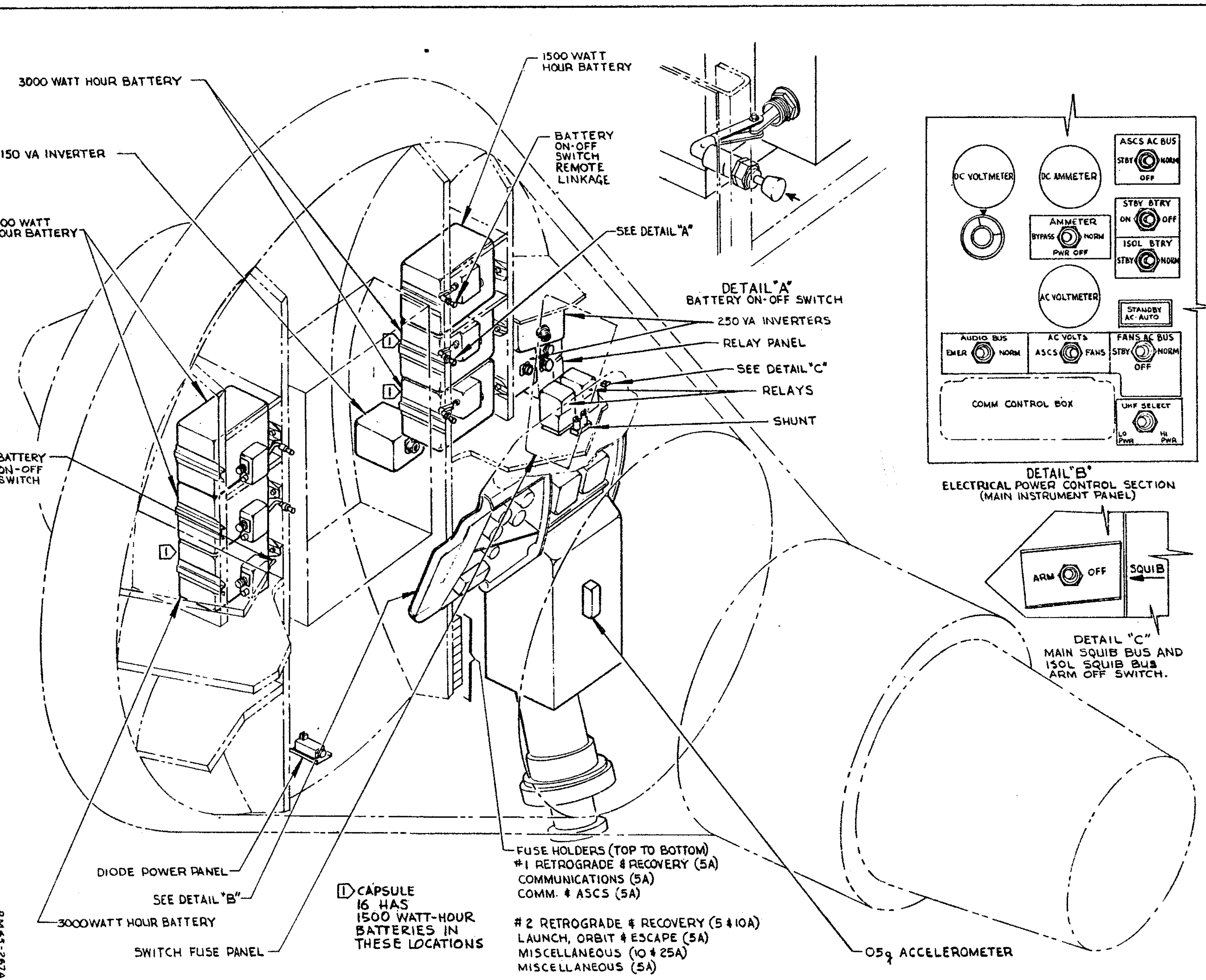


FIGURE 10-1 ELECTRICAL POWER SUPPLY SYSTEM (CAPSULES 16, 18 AND 19)

PM 45-267A

CONFIDENTIAL

X. ELECTRICAL POWER AND INTERIOR LIGHTING SYSTEMS

10-1. ELECTRICAL POWER SYSTEM

10-2. SYSTEM DESCRIPTION

The capsule power supply consists of three main batteries, two standby batteries and one isolated battery which supply 6, 12, 18 and 24 volts d-c through control circuitry to the d-c power distribution busses. Distribution is accomplished through high priority and low priority busses. Low priority busses may be switched off to conserve battery power. External d-c power is supplied through a diode panel prior to launch. (See Figures 10-1 and 10-2.) The capsule ammeter is used to indicate bus current when capsule power is applied. Capsule bus voltage may be read on the capsule d-c voltmeter when external power or battery power is supplying the busses.

The d-c electrical loads are supplied through fuses, except the "Abort" Control which incorporates a solid conductor in place of a fuse. Some of the d-c circuits utilize two fuses in parallel for redundancy, with a two position switch which permits operation in the normal (No. 1) position or the emergency (No. 2) position. In addition, to prevent possible loss of power during an emergency, a solid conductor is installed in place of a fuse in the emergency (No. 2) position of the following circuits.

(a) Emerg. Capsule Separation Control

(b) Tower Separation Control

(c) Emerg. Main Chute Deploy

(d) Retro. Jett. Control

(e) Retro. Manual Control

(f) Reserve Chute Deploy

(g) Emerg. Reserve Chute Deploy

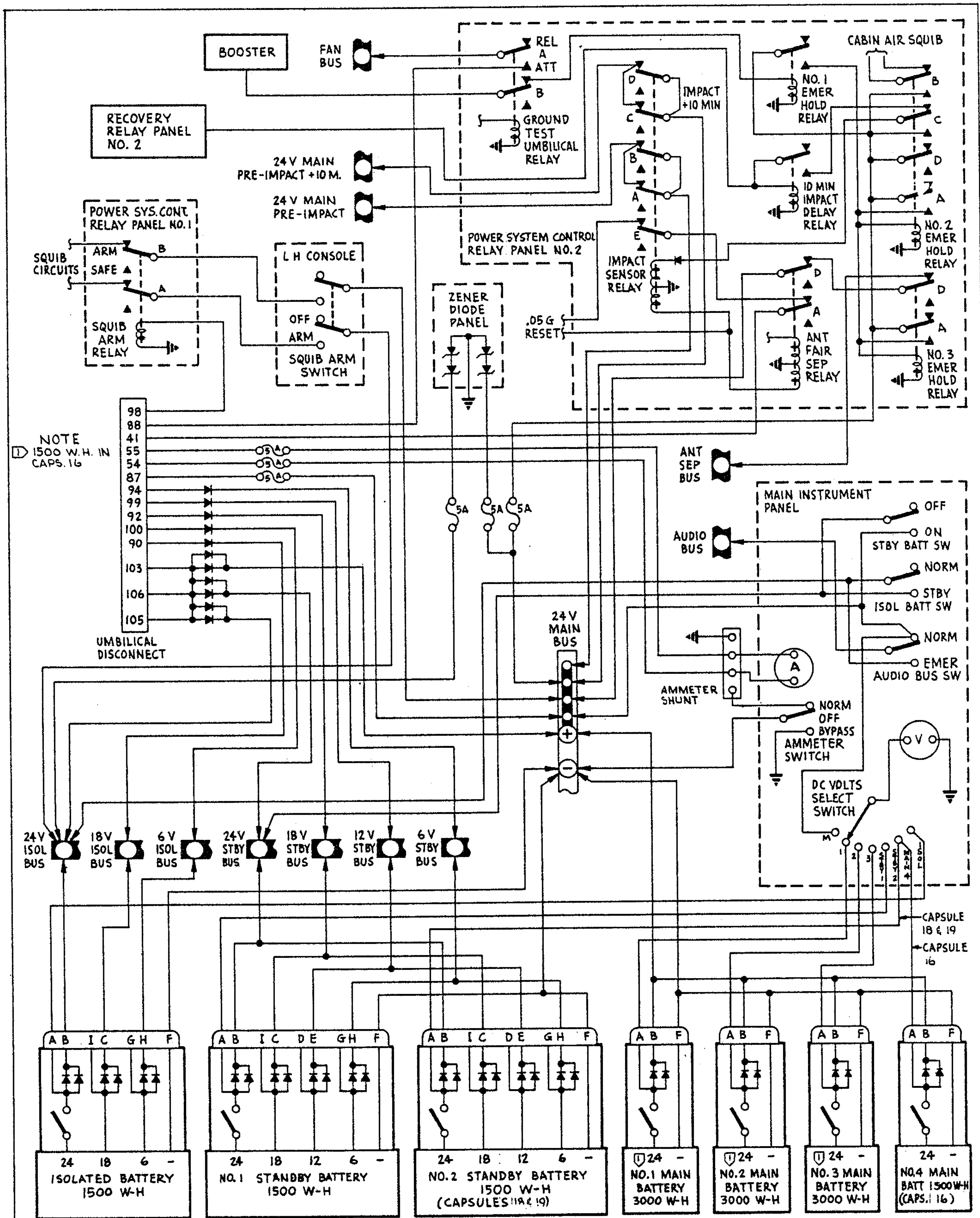


FIGURE 10-2 D-C POWER CONTROL SCHEMATIC (CAPSULES 16, 18 & 19)

PM45-88F

The a-c loads are not fused because of inherent overload protection in the inverters.

The a-c power is obtained by using two main inverters and one standby inverter to transform battery voltage to 115 volt, 400 cycle, single phase a-c. The a-c voltage is fed through control circuitry to the a-c distribution busses.

10-3. SYSTEM OPERATION

10-4. D-C POWER CONTROL

The main 24 volt d-c power supply consists of three 3000 watt-hour batteries. (See Figure 10-2). Each battery is connected in parallel to the circuit by an ON-OFF switch on the battery. Individual reverse current diode protection prevents discharge through a faulty or low battery. The 24 volt d-c power from the three main batteries, or from the external power source prior to launch, is supplied to the main d-c bus. The main 24 volt d-c bus is connected directly to the 250 and 150 volt inverter filter inputs.

Two 1500 watt hour standby batteries are installed in the capsule to supply communications bus voltage and to act as standby power for the main system. The standby batteries incorporate diode reverse current protection and are connected to the circuit through ON-OFF switches located on the batteries.

Standby-battery taps, through diodes, supply 6, 12 and 18 volts d-c to the various system busses. Prior to launch these circuits are energized by external power through the umbilical disconnect and external power diode package. Standby battery 24 volt d-c power application is controlled by the STDBY BATT. switch on the main instrument panel. This switch may be placed in the OFF or ON position. In the OFF position, the main batteries supply 24 V d-c power to the capsule electrical systems through the main bus. In the "ON" position, the standby 24 V d-c bus is connected directly to the main bus and both battery groups supply power to the capsule systems in parallel. (See Figure 10-2). An emergency hold circuit is utilized in event a HOLD command is initiated after umbilical separation. To reduce cabin heating and provide external observation through the periscope the emergency hold circuit removes power from the non-essential circuits and also applies power to the cabin vent squibs and to the extend motor of the periscope. Circuit switching is accomplished as follows: The hold signal from the booster is applied through normally closed contacts of the ground test umbilical relay to the solenoid of the No. 1 emergency hold relay. Power from the main d-c bus is then applied through the normally open contacts of No. 1 emergency hold relay to the solenoid of No. 2 and No. 3 emergency hold relays. Actuation of these relays, removes power from some of the non-essential circuits, and energizes the impact sensor relay. At the same time, power is applied through the normally open contacts of the emergency hold relays to extend the periscope, and fire the cabin vent squibs.

A 1500 watt-hour Isolated battery is installed to provide emergency audio bus and squib firing voltages and to supply emergency voltages to other circuits in event the main and standby batteries are depleted. The isolated battery also incorporates reverse current protection and is connected to the isolated bus through an ON-OFF switch. Isolated battery taps supply 6 and 18 volts d-c through self-contained diodes, to selected system busses. The 24 volt isolated battery output is available through the ARM position of the squib arming switch and through the EMERG position of the AUDIO BUS switch to the associated busses. The Isolated 24 volt d-c output may also be connected in parallel with the 24 volt output of the standby batteries through the STDBY position of the ISOL-BTRY switch.

External d-c power is supplied through the umbilical cable to capsule circuitry. This power is used for pre-launch operations in order to conserve the capsule battery supply. Normally 6, 12, 18 and 24 volts d-c are supplied through seven inputs to the external power diode panel, however, only four external power supplies are used to supply the 6, 12, 18 and 24 volt requirements. A d-c voltmeter and selector switch permit the Astronaut to read individual battery and main bus voltages as desired. The d-c ammeter is used, with the ammeter switch in the NORM position to indicate d-c load current from the batteries in the circuit. A zener diode panel is incorporated connecting zener diodes between ground and each of the Main and Isolated 24 d-c Busses which provides protection for the transistorized equipment from transient spike voltages (See Figure 10-2).

10-5. A-C POWER AND CONTROL

10-6. Main Inverter

Main 115 volt 400 cycle a-c power is supplied by two inverters of 150 volt-amperes and 250 volt-amperes. The a-c load is divided into two groups namely the ASCS bus and the FANS bus. The 250 VA inverter supplies the ASCS bus and the 150 VA inverter supplies the FANS bus. The main d-c bus powers the 150 VA (fans bus) inverter through a filter circuit and a 25 ampere fuse. The 250 VA inverter (ASCS bus) is also powered from the main d-c bus through a line filter and 25 ampere fuse. The d-c power is controlled through the NORM. position of the ASCS, AC Bus, and Fans AC Bus switches on the Main Instrument Panel. The outputs of the FANS and ASCS inverters feed the solenoids of the Fans Bus Relay and the ASCS Bus Relay. These energized relays feed the inverter output through the closed contacts of the relays to power the fans and ASCS busses. (See Figure 10-3.)

10-7. Standby Inverter

Standby 115V 400 cycle a-c power is supplied by one 250 volt ampere standby

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

~~CONFIDENTIAL~~

DATE 1 NOVEMBER 1961
REVISED
REVISED

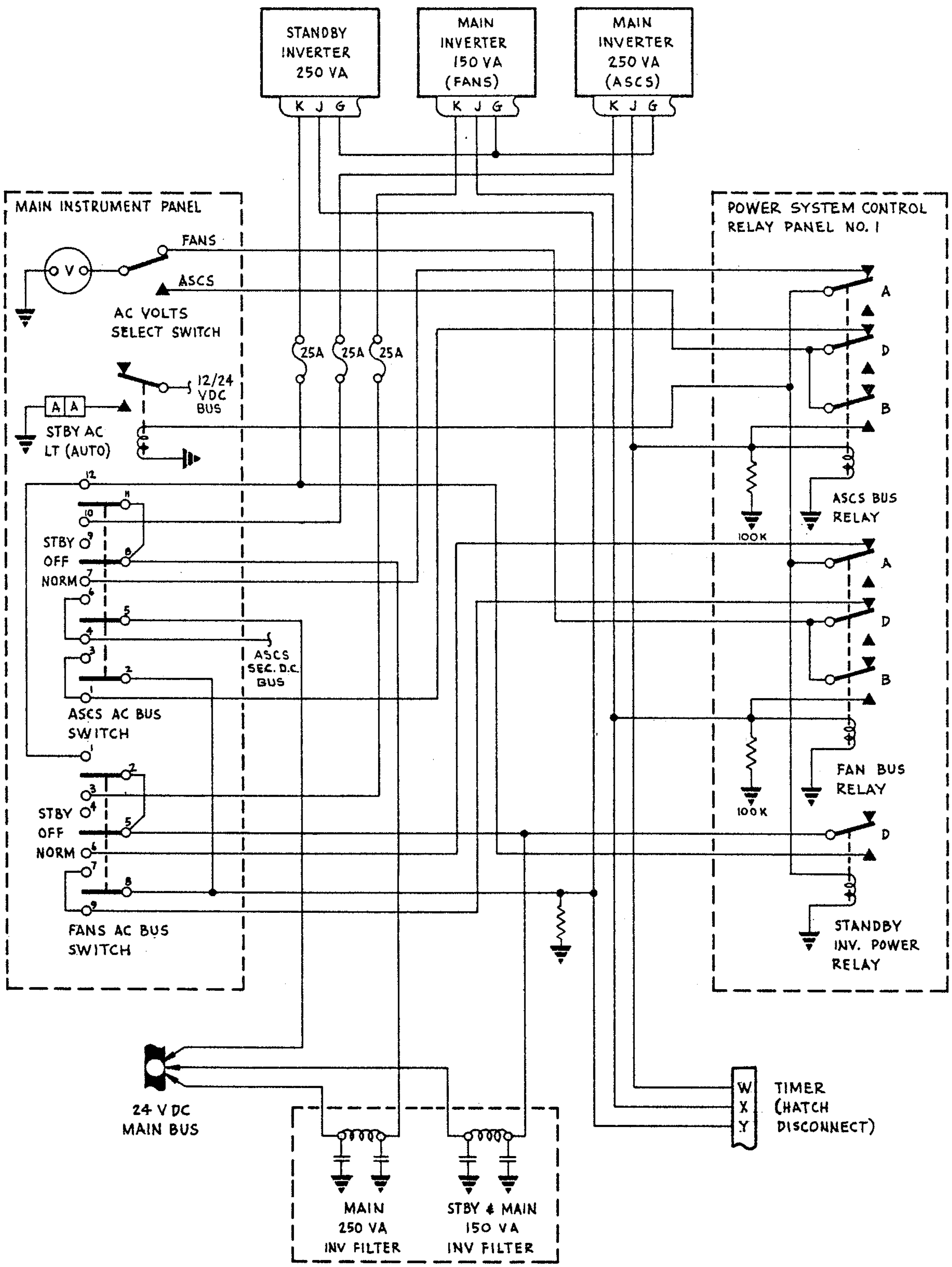


FIGURE 10-3 A-C POWER CONTROL SCHEMATIC (CAPSULES 16,18 & 19)

PM45-215B

~~CONFIDENTIAL~~

inverter. The standby inverter will supply a-c power to either, or both, ASCS and Fans A-c busses by selecting the STANDBY position on the respective ASCS or Fans Bus switch located on the main instrument panel.

In event of failure of either the 250 VA or 150 VA Main inverters the respective Fan Bus relay or ASCS Bus relay will be de-energized. This action will automatically energize the Standby Inverter Relay which in turn will apply d-c power from the filter to the standby inverter. The a-c output from the standby inverter is then directed through contacts in the de-energized ASCS or Fans Bus Relays to their respective busses. A warning light on the Main Instrument Panel indicates when the Standby Inverter is switched into operation by reason of failure of either of the main inverters. (See Figure 10-3.)

10-8. POWER DISTRIBUTION

10-9. D-C POWER DISTRIBUTION

D-C power is taken from three separate battery groups, namely the main battery, standby battery and isolated battery. Various sub busses which operate from these sources and the bus separation method are as follows:

(a) Main d-c bus directly to the main batteries.

(b) Main 24 V d-c antenna separation bus from main bus through separation relay.

(c) Pre-impact plus 10 minute from main bus through impact relay.

(d) Main 24 V squib bus through SQUIB ARM SW from main bus.

(e) Pre-impact main bus through impact relay from main bus.

(f) Audio bus from main bus or isolated bus through AUDIO BUS SW (3 position, center OFF).

(g) Isolated d-c bus directly to isolated battery.

(h) Standby d-c bus directly to standby battery.

(i) Isolated 6 and 18 volt busses directly to taps on isolated battery.

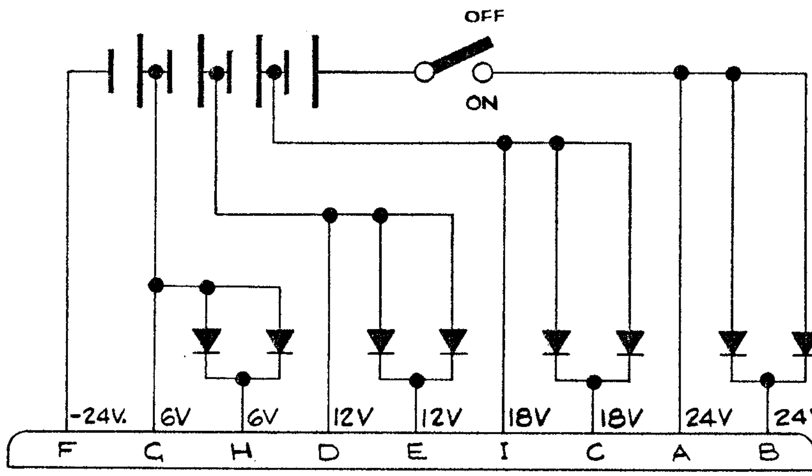
McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

~~CONFIDENTIAL~~

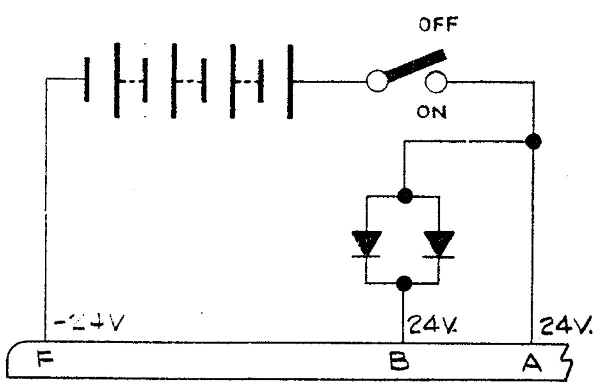
DATE 1 NOVEMBER 1961
REVISED
REVISED

NOTES

[1] MAY BE INSTALLED IN CAPSULE FOR GROUND TESTS OR FLIGHT
[2] MAY BE INSTALLED IN CAPSULE FOR GROUND TESTS
[3] DO NOT INSTALL IN CAPSULE. MAY BE ACTIVATED AND USED FOR POWER SYSTEM TESTS, GROUND CART FOR "THRU THE HATCH POWER" AND BATTERY CHARGER TESTS



[3] EAGLE PICHER MAR 4028-1, MAC 45-79707-15 (1500 WH)
[1] EAGLE PICHER MAR 4027-B, MAC 45-79707-21 (3000 WH)
[3] EAGLE PICHER MAR 4028-A, MAC 45-79707-19 (1500 WH)
[1] EAGLE PICHER MAR 4028-B, MAC 45-79707-19 (1500 WH)
[2] EAGLE PICHER MAR 4028-B, MDE 4587020-5 (1500 WH)



[1] EAGLE PICHER MAR 4027C, MAC 45-79707-17 (3000 WH)
[3] EAGLE PICHER MAR 4027-1, MAC 45-79707-13 (3000 WH)
[3] EAGLE PICHER MAR 4027A, MAC 45-79707-17 (3000 WH)
[2] EAGLE PICHER MAR 4027C, MDE 4587020-3 (3000 WH)

FIG 10-4 BATTERY INTERNAL WIRING DIAGRAM

PM 45-93A

~~CONFIDENTIAL~~

put in an ambient atmosphere of 160°F or at 80°F at 5 psia 100% oxygen. The output is 115 volts a-c ± 5%, single phase to ground, with a frequency of 400 cycles ± 1.0% and essentially sinusoidal in wave-form. A short circuit across the output of an inverter will not damage the inverter or the wiring involved in short circuit.

10-14. D-C AMMETER 0-50 AMPERE

The d-c ammeter is located on the main instrument panel and provides the Astronaut with an indication of total current drain from all batteries. The basic ammeter movement has a 50 millivolt sensitivity. A shunt of suitable resistance is connected across the input of the meter providing a low resistance path to ground with proper voltage drop for the meter movement.

10-15. D-C VOLTMETER 0-30 VOLTS

A d-c voltmeter, and its selector switch, are located on the main instrument panel. Approximate battery condition can be determined by placing the D-C VOLTS switch to the appropriate positions and reading the individual battery voltages.

10-16. TEST CONFIGURATION CAPSULES

Deviations from data applicable to the Test Configuration Capsules are explained in the following paragraphs and if no data is presented for a particular item, this item is the same as that used on the Specification Compliance Capsule.

10-17. TEST CONFIGURATION CAPSULE NO. 8

The Electrical Power System on Capsule No. 8 is the same as the Specification Compliance Capsule except for differences as noted in the following paragraphs. (See Figure 10-6 for major components installed.)

10-18. System Description

The Capsule Power Supply in Capsule No. 8 consists of three 3000 watt-hour

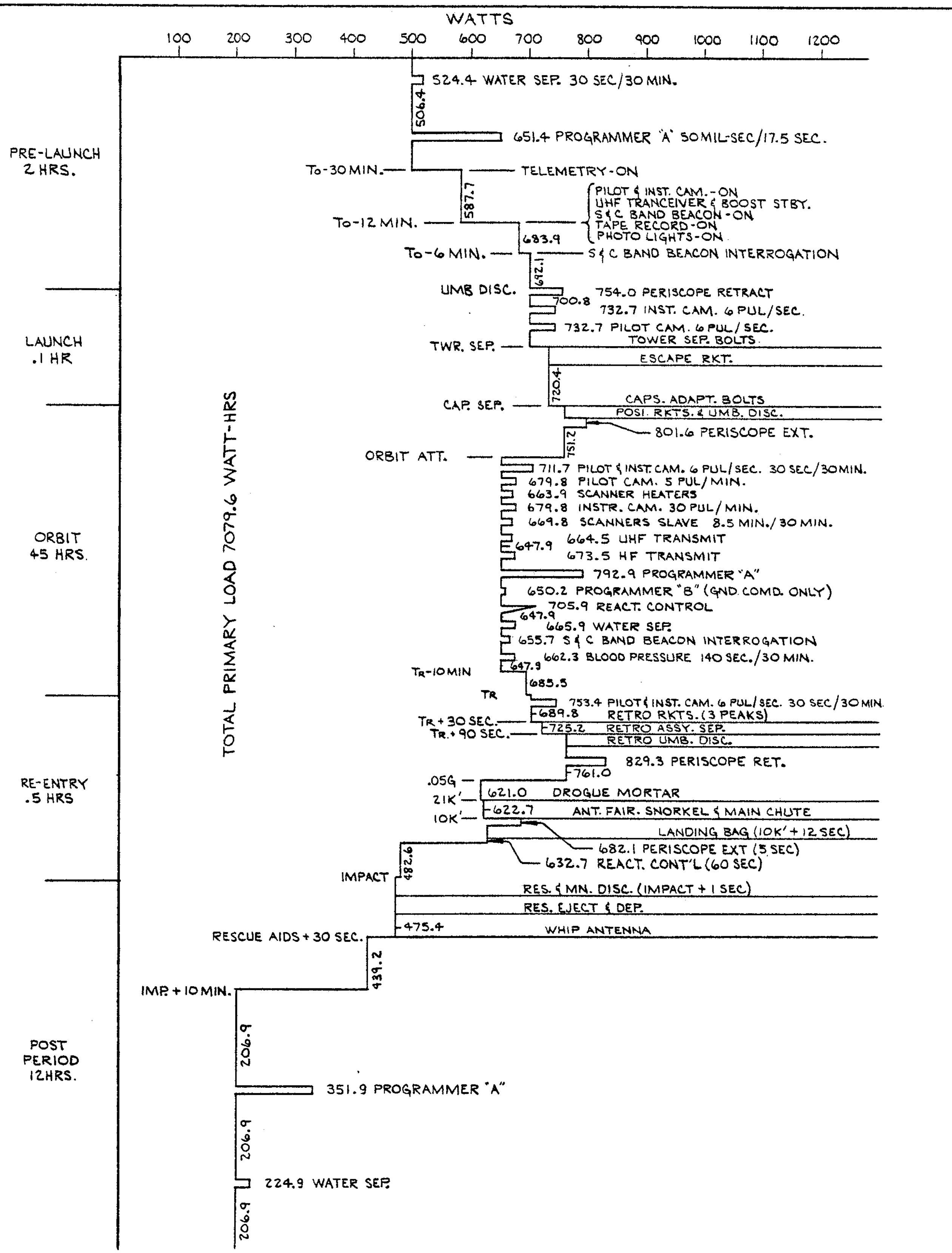


FIGURE 10-5 D-C WATT HOUR LOADING (CAPSULES 10, 16, 18 & 19)

PM45-274

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

~~CONFIDENTIAL~~

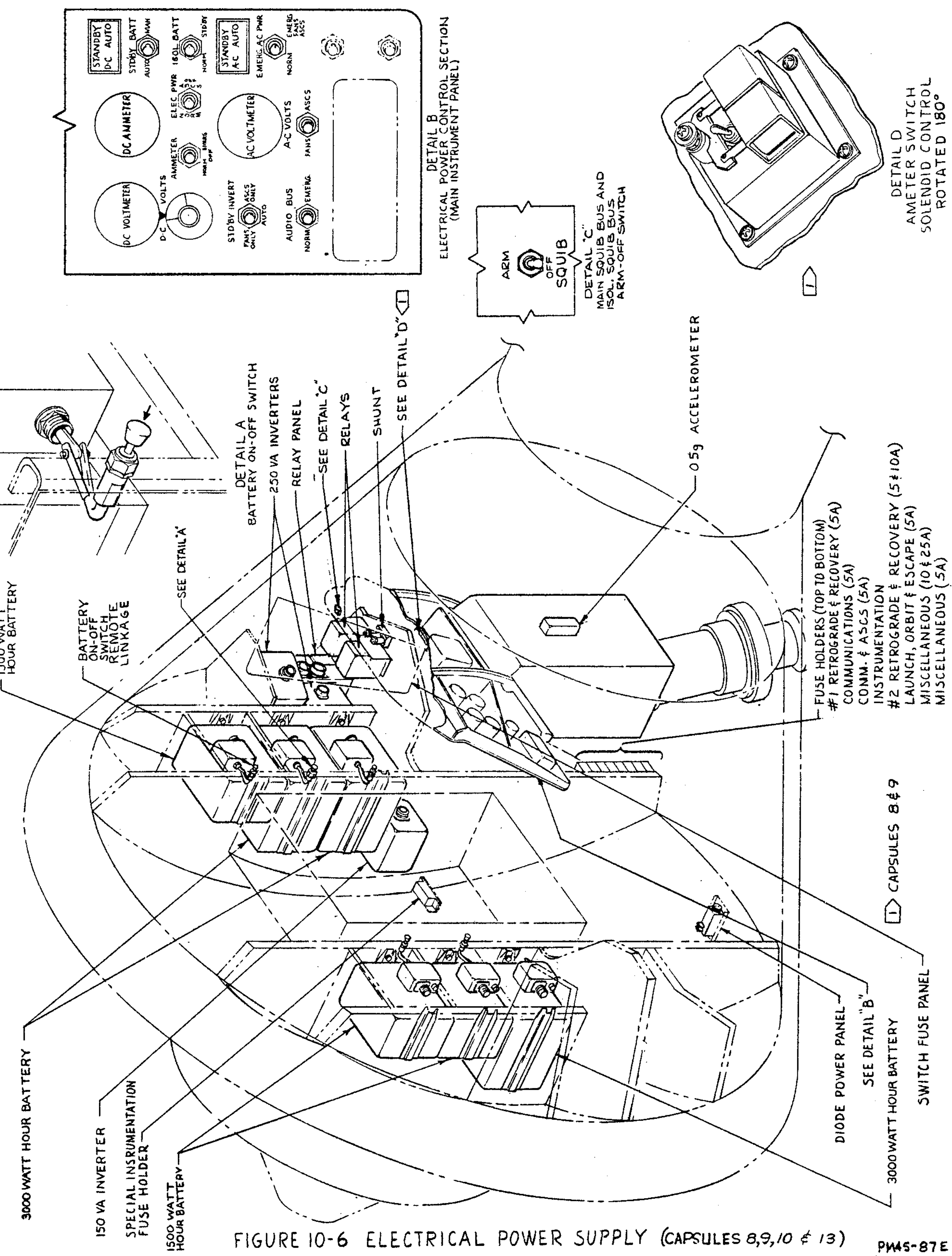


FIGURE 10-6 ELECTRICAL POWER SUPPLY (CAPSULES 8,9,10 & 13)

PM45-87E

~~CONFIDENTIAL~~

main batteries, one 1500 watt-hour Main battery, one 1500 watt-hour standby battery, and one 1500 watt-hour isolated battery. (See Figure 10-7.)

D-c electrical loads are supplied through fuses except to the (1) Retrograde Seq. control, (2) Emerg. Capsule Separation, (3) Abort Control, and (4) Auto Landing System A circuits - these circuits incorporate solid conductors in place of fuses. Some of the d-c circuits utilize two fuses in parallel for redundancy, with a two position switch which permits operation in the normal (No. 1) position, or the emergency (No. 2) position. In addition, to prevent possible loss of power during an emergency, a solid conductor is installed in place of a fuse in the emergency (No. 2) positions of the following circuits:

(a) Retro Manual Control (No. 1 and No. 2)

(b) Reserve chute deploy - Systems A and B

(c) Tower separation control.

A-c loads are not fused because of inherent overload protection in the inverters.

10-19. D-C Power Control

Capsule special instrumentation uses two of the four main batteries. The normal connector plugs on the No. 3 and No. 4 main batteries are tied back at bundles 800A and 801B. Special instrumentation bundles 867 SI and 836 SI, respectively, are connected to the No. 3 and No. 4 batteries.

The main 24 volt d-c power supply consists of only two main batteries. (See Figure 10-7.) Each battery is connected in parallel to the circuit by an ON-OFF switch on the battery. Individual reverse current diode protection prevents discharge through a faulty or low battery. The 24 volt d-c power from the two main batteries, or from the external power source prior to launch, is applied to the main d-c bus. The main d-c bus is connected through the secondary bus relay to the secondary bus.

The 1500 watt-hour standby battery is installed in the capsule to supply

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

~~CONFIDENTIAL~~

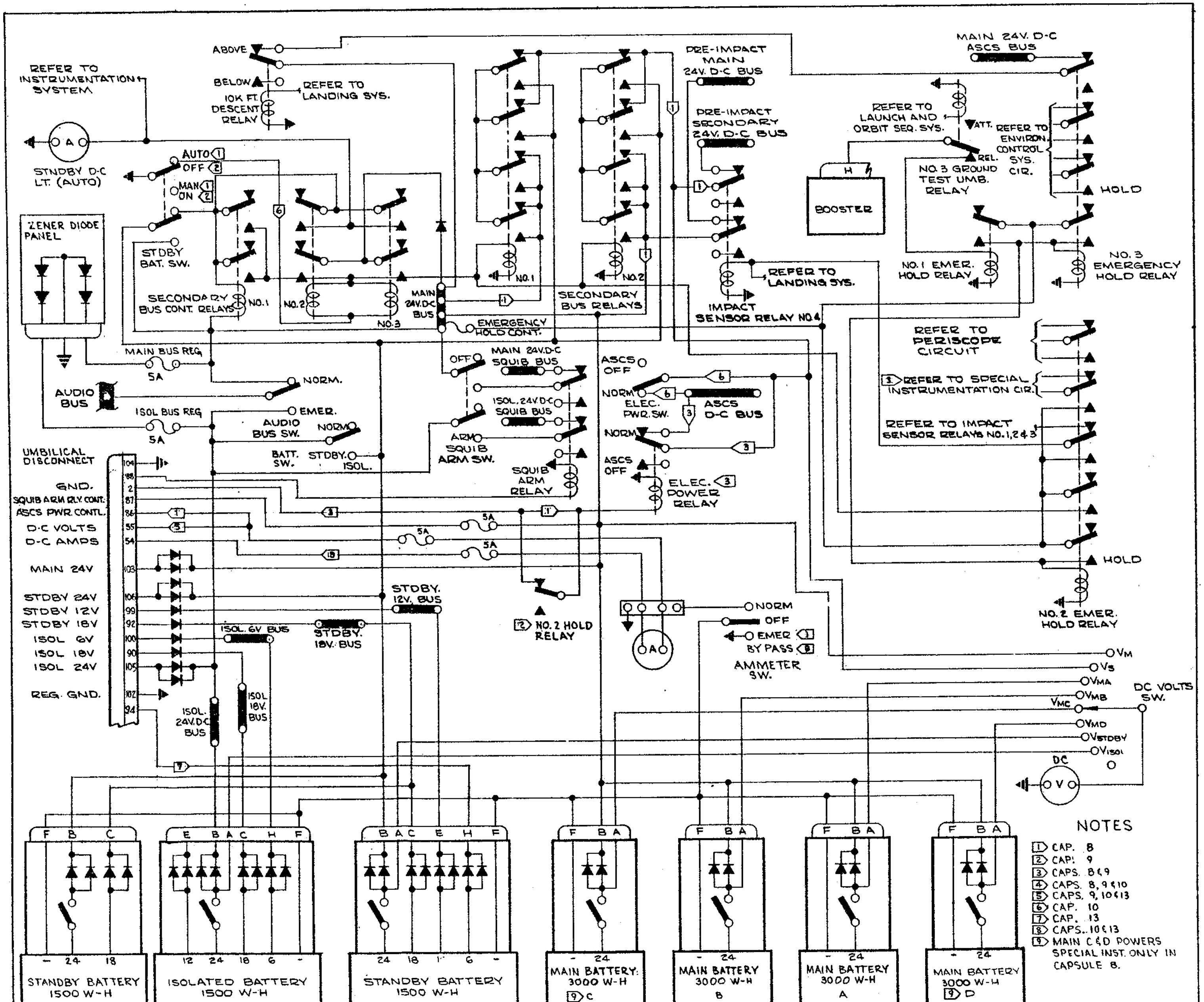


FIGURE 10-7 D-C POWER CONTROL SCHEMATIC (CAPSULES 8, 9, 10 & 13)

~~CONFIDENTIAL~~

communications bus voltage and to act as standby power for the main system. The standby battery also incorporates diode reverse current protection and is connected to the circuit through an ON-OFF switch located on the battery.

Standby battery taps through diodes, supply 6, 12 and 18 volts d-c to the various system busses. Prior to launch these circuits are energized by external power through the umbilical disconnect and external power diode package. Standby battery 24 volt d-c power application is controlled by the STDBY BATT switch on the main instrument panel. This switch may be placed in the AUTO or MANUAL position. In the AUTO position, a decrease in main battery voltage to a level somewhat below standby battery voltage causes the No. 1 secondary bus control relay to energize. Power is applied through normally open contacts of this relay to energize the No. 2 and No. 3 secondary bus control relays. These relays have holding contacts which lock their solenoids to the main d-c bus. With the No. 2 and No. 3 control relays energized, power is applied to the solenoids of the secondary bus relays. Energizing the secondary bus relays removes voltage from the secondary bus and connects the standby battery 24 volt output to the main bus in parallel with the reduced main battery output. The secondary bus relay also energizes the STANDBY D-C AUTO indicator light indicating automatic use of the standby battery. Signal voltage indicative of STANDBY D-C AUTO lamp operation is supplied to the instrumentation system.

The MAN position of this STDBY BATT switch connects the standby battery 24 volt output directly to the main 24 volt d-c bus and through the secondary bus relay to the secondary 24 volt d-c bus. No visual indication is made of this use of the standby battery other than Astronaut checks of current and voltage. An emergency hold circuit is utilized in the event of a "hold" command after umbilical separation. To reduce cabin heating the emergency hold circuit removes power from the secondary and the main ASCS busses and applies

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

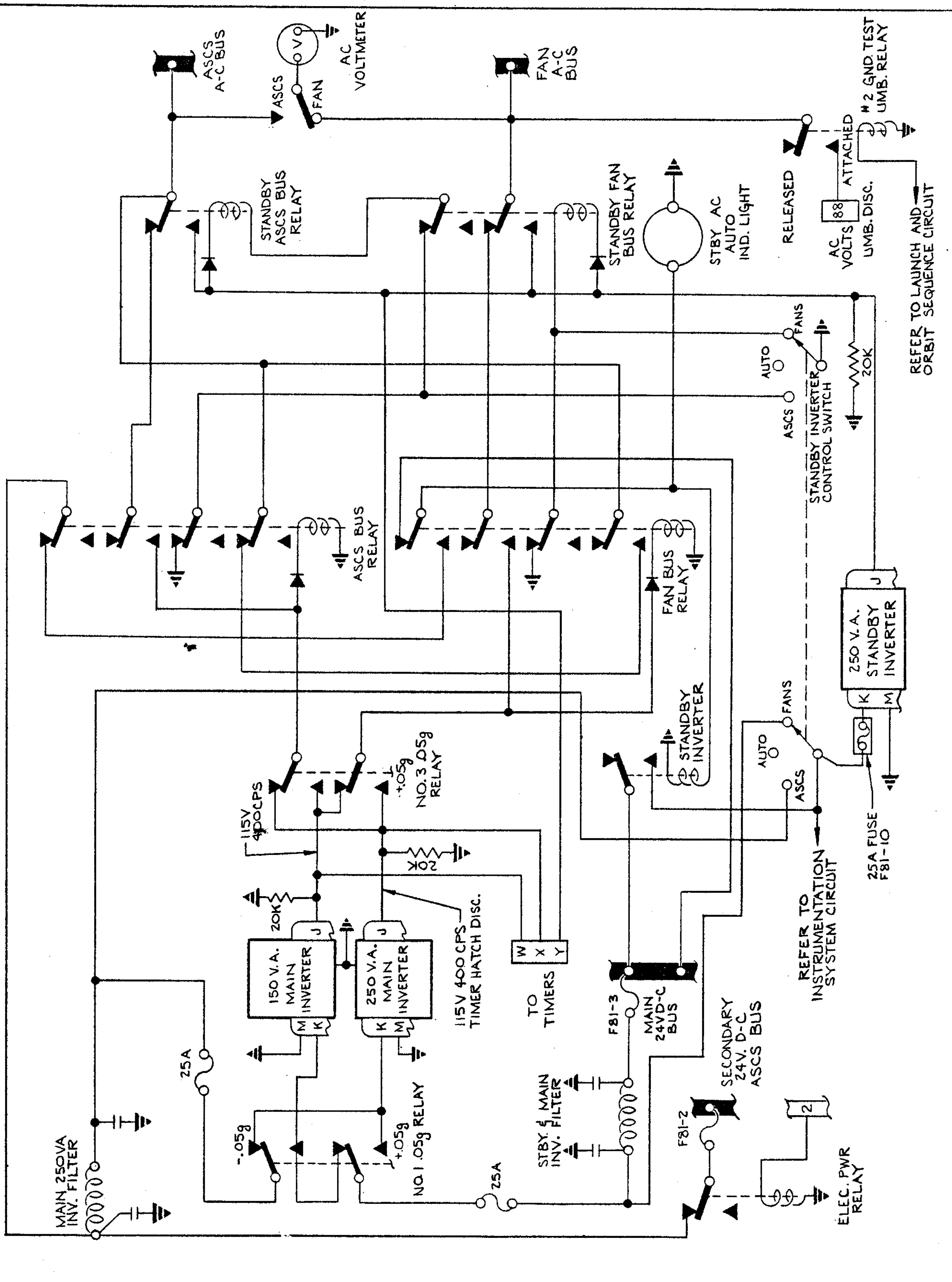


FIGURE 10-8 A-C POWER CONTROL SCHEMATIC (CAPSULE NO. 8)

PM45-89E

power to the cabin vent squibs and to the extend motor of the periscope. Circuit switching is accomplished as follows. The "hold" signal from the booster is applied through normally closed contacts of the No. 3 ground test umbilical relay to the solenoid of the No. 1 emergency hold relay. Power from the main d-c bus is applied through normally open contacts of the No. 1 emergency hold relay to the solenoids of the No. 2 and No. 3 emergency hold relays. Normally open contacts of the No. 2 emergency hold relay apply power to the solenoids of the secondary bus relays, impact sensor relay and to the extend motor of the periscope. Other normally open contacts of the No. 3 emergency hold relay apply power to the cabin vent squibs and remove power from the main 24 volt ASCS bus. (See Figure 10-7.)

10-20. A-C Power and Control

10-21. Main Inverters

Main, 115 volt, 400 cycle a-c power is supplied by one 250 volt ampere inverter and one 150 volt ampere inverter. (See Figure 10-8.) The a-c load is divided between the ASCS bus and the fan bus. During flight when the ASCS is the primary a-c load, the 250 volt ampere inverter powers that bus while the 150 volt ampere inverter powers the fan bus. During re-entry, at approximately 300,000 feet, the fan system becomes the primary a-c load. Therefore, the inverters are switched such that the higher capacity inverter powers the fan bus. The main d-c bus supplies input power to the inverter feeding the fan bus while the secondary d-c bus supplies input power to the inverter feeding the ASCS bus. The output from one inverter energizes the ASCS BUS RELAY while the output of the other inverter energizes the FAN BUS RELAY. Inverter output is then supplied through the energized bus relays to the appropriate bus. An A-C VOLTMETER is provided with a spring loaded A-C VOLTMETER SWITCH which normally closes the voltmeter circuit to the fan bus and must be manually operated to read ASCS bus voltage.

10-22. Standby Inverter

Standby, 115 volt, 400 cycle a-c power is supplied by one 250 volt ampere inverter. The STANDBY INVERTER switch determines which d-c bus shall supply the standby inverter input voltage and whether the a-c output voltage shall power the ASCS bus or the fan bus or shall automatically power either bus in the event of main inverter failure. With the STANDBY INVERTER SWITCH in the ASCS ONLY position, the standby inverter is energized by 24 volts d-c from the secondary d-c bus. The standby inverter output energizes the STANDBY ASCS BUS RELAY. The energized STANDBY ASCS BUS RELAY removes the main inverter output from the line and applies the standby inverter output.

When the STANDBY INVERTER switch is in the FANS position the standby inverter is energized by 24 volts d-c from the main d-c bus. The standby inverter output energizes the STANDBY FAN BUS RELAY. The energized STANDBY FAN BUS RELAY removes the main inverter output from the line and applies the standby inverter output.

The AUTO position of the STANDBY INVERTER CONTROL SWITCH allows the inverter to power either a-c bus should the main inverter feeding one of them fail. Failure of a main inverter causes the associated bus relay to de-energize. This connects the standby inverter input to the d-c bus used by the failed main inverter and feeds the output to the proper a-c bus. The STANDBY A-C AUTO light illuminates during standby inverter operation while in the automatic mode. Should both main inverters fail while in automatic mode, the standby inverter, operating from the main d-c bus, will power the fan a-c bus. Signal voltage indicative of STANDBY A-C AUTO light operation is supplied to the instrumentation system.

No Emergency A-C Power switch is provided for use in Capsule No. 8. Instead, 24 volts d-c is connected directly through the No. 1 0.05g relay into the

150 VA Main Inverter.

10-23. D-C Power Distribution

On Capsule No. 8, d-c power is taken from three separate battery groups, namely the main battery, standby battery and isolated battery. Various sub busses which operate from these sources and the bus separation method are as follows. See Figure 10-7 for special instrumentation battery usage.

(a) Secondary d-c bus supplied by main d-c bus through secondary bus relay.

(b) Secondary ASCS bus supplied by secondary bus through ELEC PWR RELAY.

(c) Pre-impact secondary bus through impact relay.

(d) Main 24 V squib bus through SQUIB ARM SW from main bus.

(e) Pre-impact main bus through impact relay from main bus.

(f) Audio bus from main bus or isolated bus through AUDIO BUS SW (3 position, center OFF).

(g) Isolated d-c bus directly to isolated battery.

(h) Standby d-c bus directly to standby battery.

(i) Isolated 6 and 18 volt busses directly to taps on isolated battery.

(j) Standby 6, 12 and 18 volt busses directly to taps on standby battery.

10-24. D-C Power Loading

See Figure 10-13 for graphical summary of the Primary d-c Power Loading on Capsule No. 8.

10-25. TEST CONFIGURATION CAPSULE NO. 9

The Electrical Power System on Capsule No. 9 is the same as the Specification Compliance Capsule except for differences as noted in the following paragraphs. (See Figure 10-6 for major components installed.)

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

~~CONFIDENTIAL~~

DATE 1 NOVEMBER 1961
REVISED
REVISED

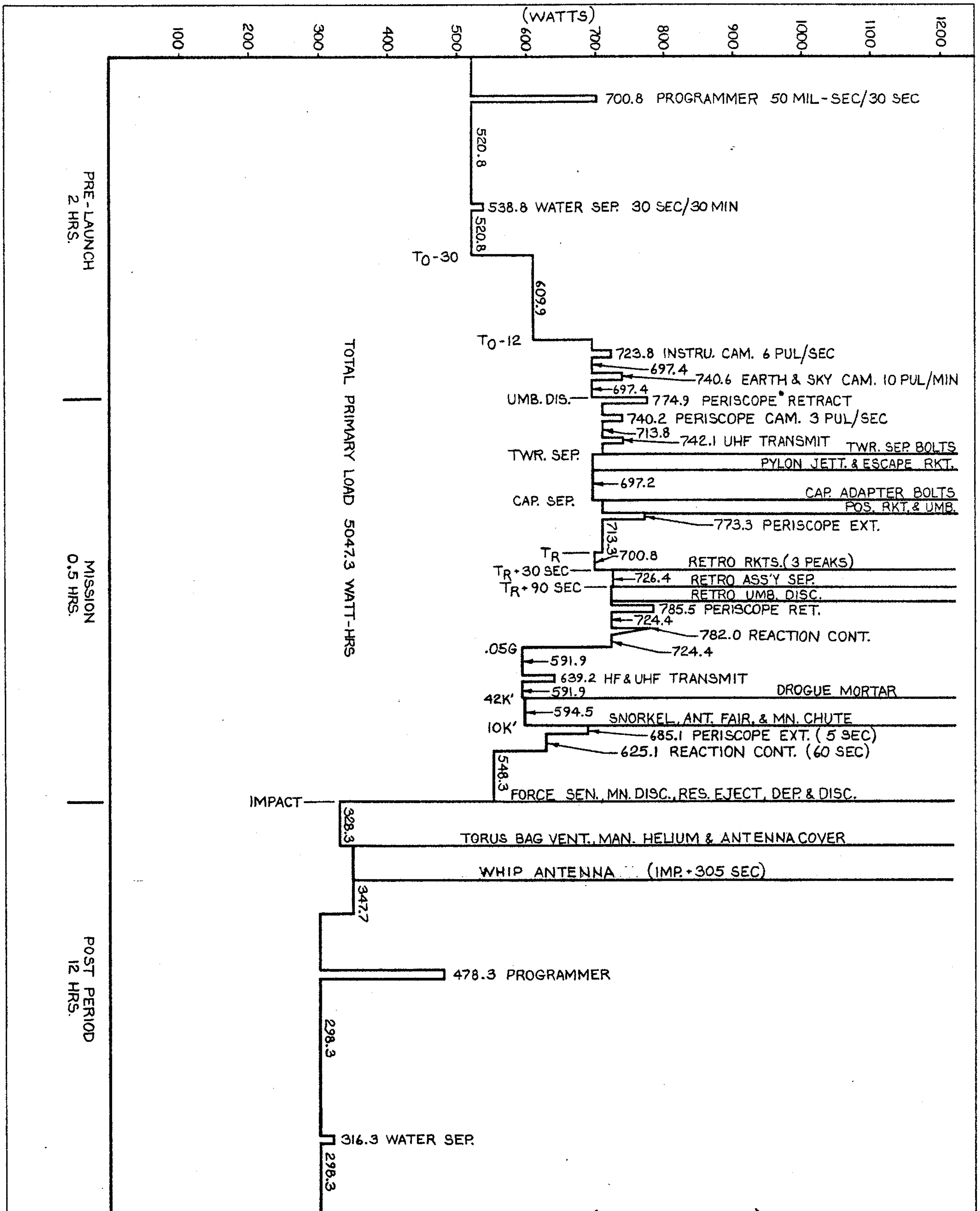


FIGURE 10-9 D-C WATT-HOUR LOADING (CAPSULE NO. 8)

PM45-209B

~~CONFIDENTIAL~~

10-26. System Description

The capsule power supply for Capsule No. 9 is similar to that used on the Specification Compliance Capsule.

10-27. D-C Power Control

The d-c power control on Capsule No. 9 is similar to that used on the Specification Compliance Capsule (Refer to Paragraph 10-4), except for the following differences. (See Figure 10-7).

On Capsule No. 9 the Secondary bus control relays No's. 1, 2 and 3, and the Secondary bus relays No's. 1 and 2 are not used. The standby battery power is connected directly to the Main d-c bus, in parallel with the main batteries, with the standby battery switch placed in the "ON" position. The standby d-c light (AUTO), or automatic switching of the standby bus to the Main bus is not used. Operation in the "ON" position of the standby battery switch as well as all other controls is the same as the Specification Compliance Capsule. The hold relay operation is the same as used on the Specification Compliance Capsule, except additional contacts are used in the No. 2 hold relay to control the power to the electrical power relay from the umbilical disconnect.

10-28. A-C Power and Control

10-29. Main Inverters

Main 115 volt 400 cycle a-c power is supplied by two inverters of 150 volt-amperes and 250 volt-amperes. The a-c load is divided into two portions namely the ASCS bus and the FANS bus. The 250 VA inverter supplies the ASCS bus and the 150 VA inverter supplies the FANS bus. The main d-c bus powers the 150 VA (fans bus) inverter through a filter circuit and a 25 ampere fuse. The 250 VA inverter (ASCS bus) is also powered from the Main d-c bus through a line filter, a 25 ampere fuse and the antenna separation relay. The Main ASCS bus is energized through the ELEC PWR relay.

(Other ASCS d-c loads are fed from the ASCS bus.) The outputs of the Main 150 VA and Main 250 VA inverters feed the solenoids of the Fans Bus Relay and the ASCS Bus Relay. These energized relays feed the inverter output through the closed contacts of the relays and through the normally closed contacts of the Standby ASCS Bus Relay to Power the fans and ASCS busses. (See Figure 10-11). The 250 VAC inverters are deactivated by the antenna fairing separation relay during descent.

10-30. Standby Inverter

Standby 115V 400 cycle a-c power is supplied by one 250 volt ampere standby inverter. The STDBY INVERT switch determines the mode of operation and/or which a-c bus shall be supplied by the standby inverter.

The EMER A-C position of the switch manually energizes the standby inverter from the ASCS bus. Standby inverter a-c power then energizes the solenoid of the Standby ASCS Bus Relay. A-c power then flows through the energized Standby ASCS Bus Relay's contacts to power the ASCS a-c bus.

The FANS ONLY position of the STDBY INV switch manually energizes the standby inverter from the main d-c bus. Standby inverter a-c power then energizes the solenoid of the Standby Fan Bus Relay. A-c power then flows through the energized standby fan bus relay's contacts to power the FANS bus. (See Figure 10-11.)

The AUTO position of the STDBY INVERT switch allows the inverter to power either a-c bus should the main inverter feeding one of them fail. Failure of a main inverter causes the associated bus relay to de-energize. This connects the standby inverter input to the d-c bus used by the failed main inverter and feeds the output to the proper a-c bus. The STDBY A-C AUTO light illuminates during standby inverter operation while in the automatic mode. Should both main inverters fail while in automatic mode, the standby inverter operating from

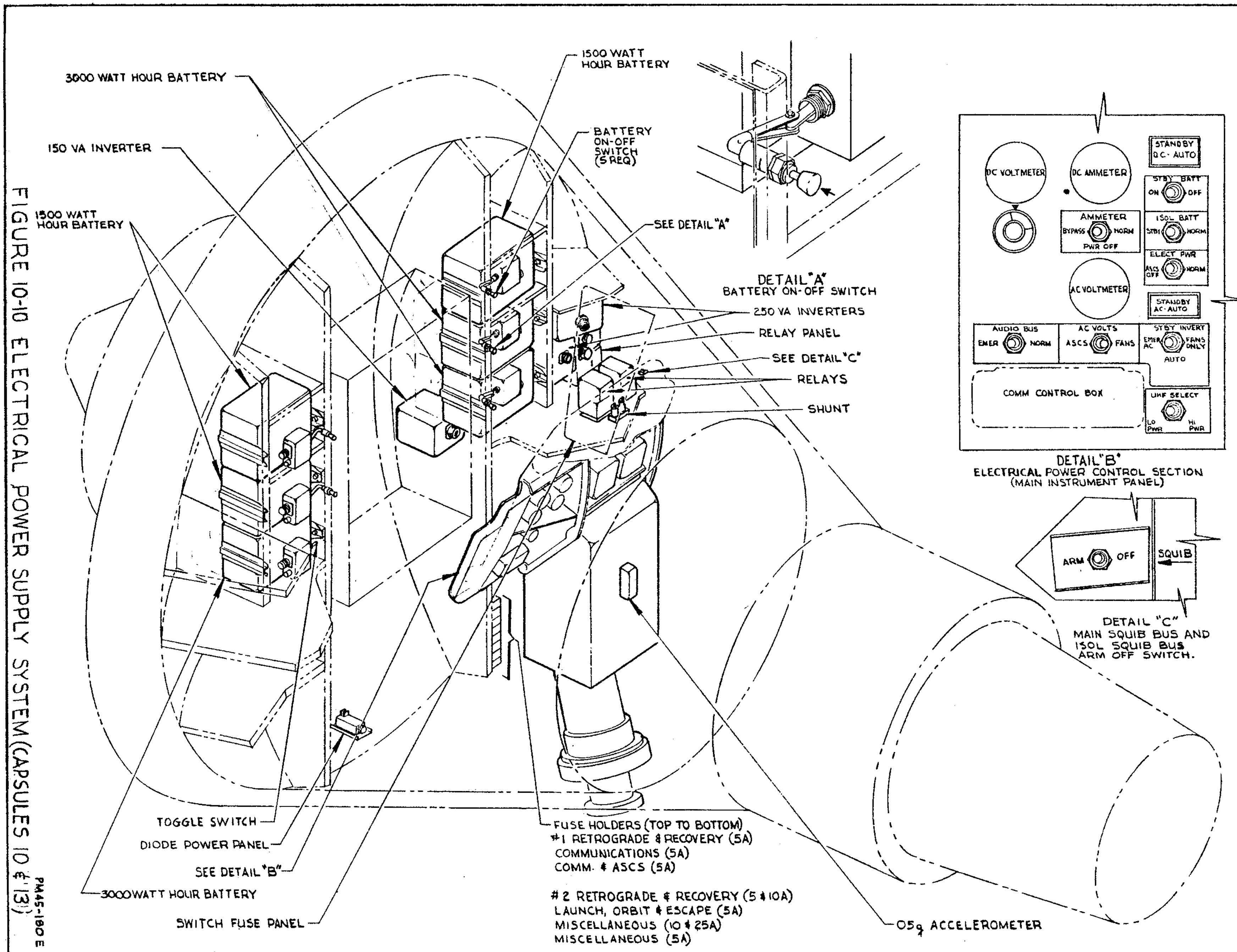


FIGURE 10-10 ELECTRICAL POWER SUPPLY SYSTEM (CAPSULES 10 & 13)

PM45-180E

CONFIDENTIAL

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

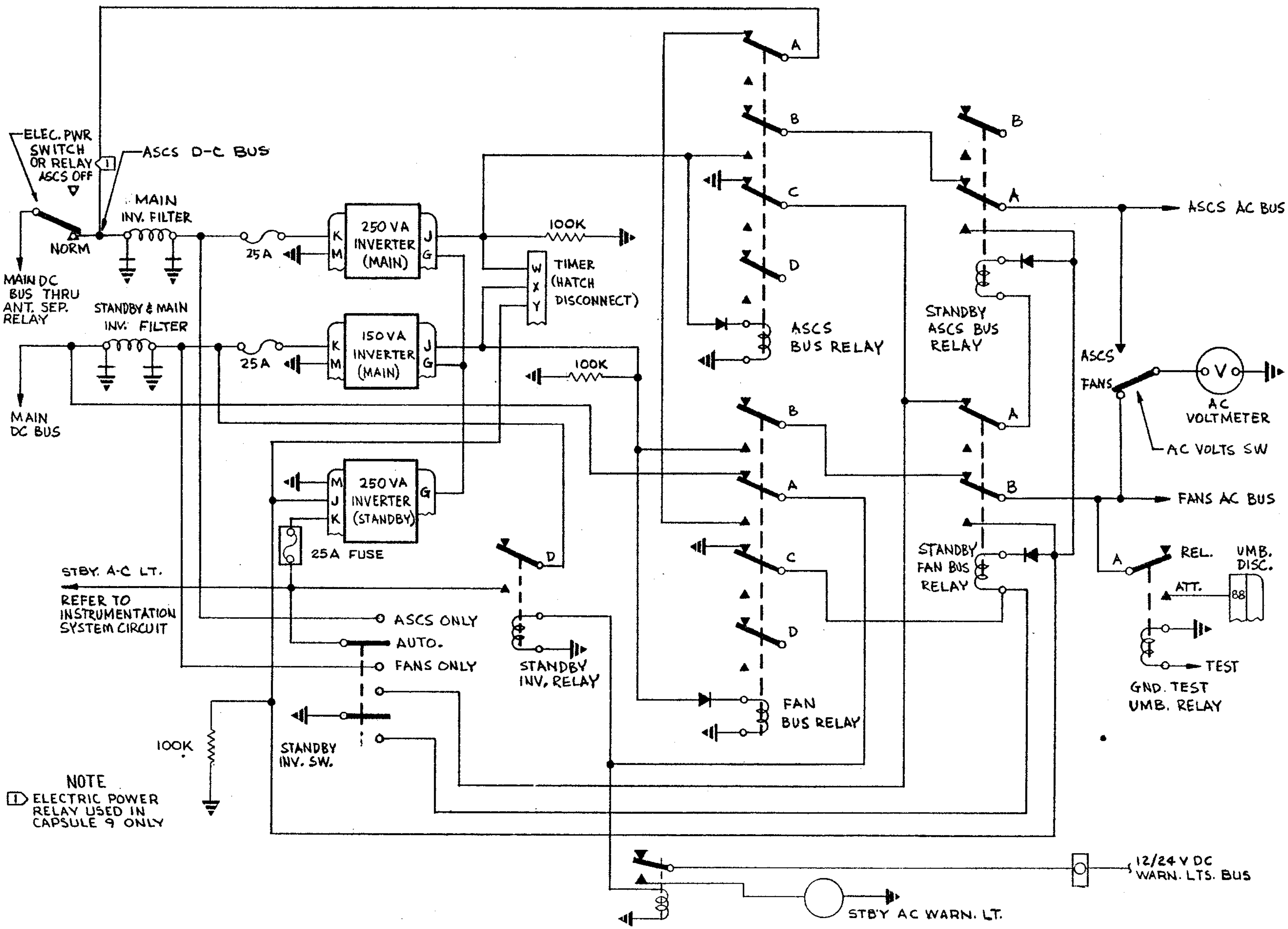


FIGURE 10-11. A-C POWER CONTROL SCHEMATIC, (CAPSULES 9, 10 & 13)

the main d-c bus, will power the fan a-c bus. Signal voltage indicative of STDBY A-C AUTO light operation is supplied to the instrumentation system.

10-31. D-C Power Distribution

The d-c power distribution on Capsule No. 9 is the same as used on the Specification Compliance Capsule (Refer to Paragraph 10-8), except for differences as shown on Figure 10-7.

10-32. D-C Power Loading

See Figure 10-10 for graphical summary of the primary d-c power loading on Capsule No. 9.

10-33. TEST CONFIGURATION CAPSULES NO. 10, 13 AND 16

The electrical power system on Capsules No. 10, 13 and 16 are the same as the Specification Compliance Capsule. (See Figure 10-5 for graphical summary of the primary d-c power loading on Capsules No. 10 and 16, and Figure No. 10-13 for Capsule No. 13.)

10-34. INTERIOR LIGHTING

10-35. <u>SYSTEM DESCRIPTION</u>

Interior lighting for the Specification Compliance Capsule consists of four fluorescent flood lights and a series of warning telelights. See Figure 10-14 for location and arrangement of cabin and system telelights.

10-36. <u>Cabin Flood Lights</u>

Two flourescent flood lights are mounted on brackets to the right and left and above the Astronaut. Power for the cabin lights is supplied from the 115 V a-c Capsule inverter Fans Bus and controlled by a three position switch located on the left console, the switch positions are marked "BOTH" "L.H. Only" and "OFF". The cabin flood lights are of high actinic value, especially suitable for camera usage. The lights produce little heat and have a low wattage

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

~~CONFIDENTIAL~~

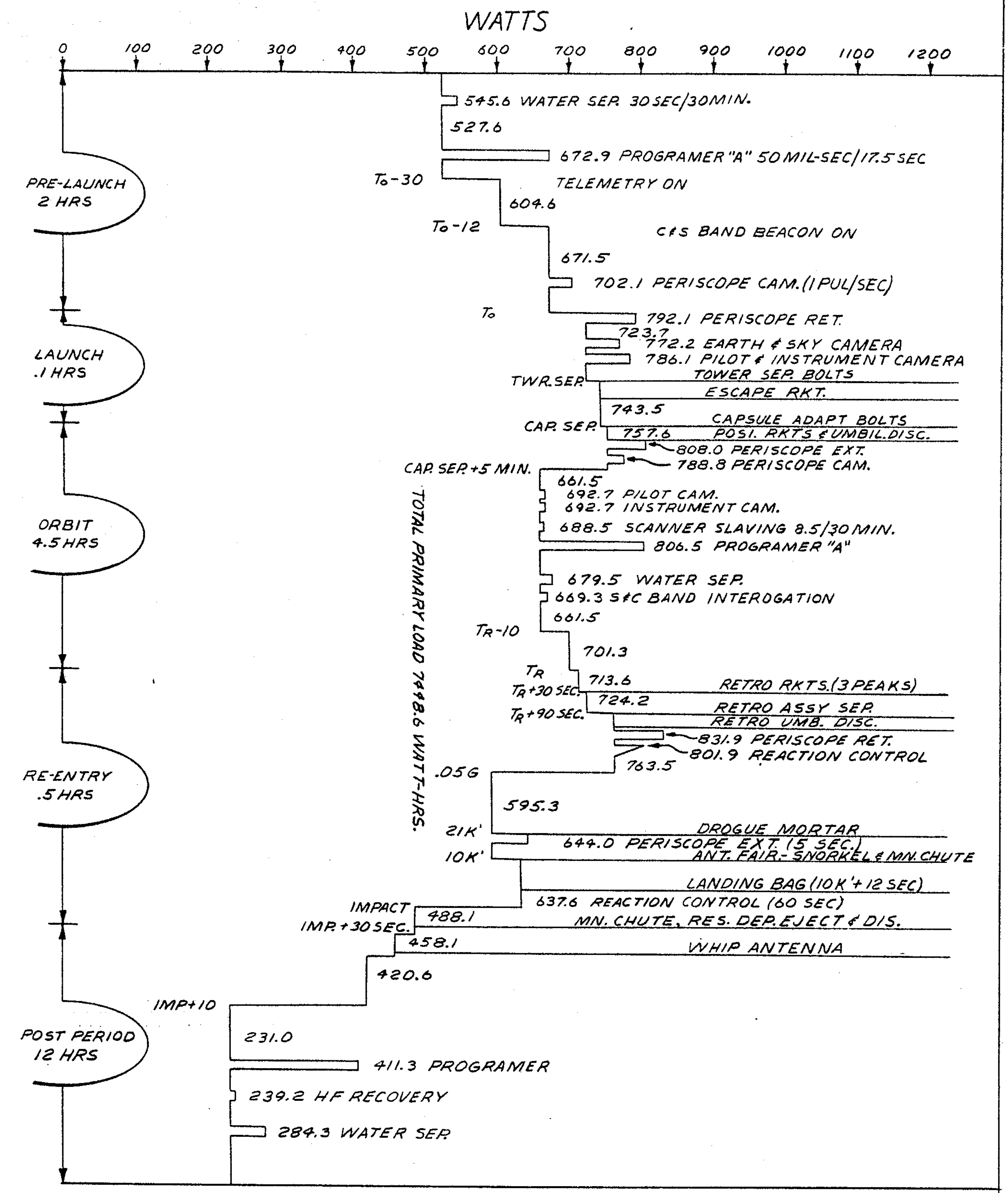


FIGURE 10-12 D-C WATT-HOUR LOADING (CAPSULE NO. 9)

PM45-255

~~CONFIDENTIAL~~

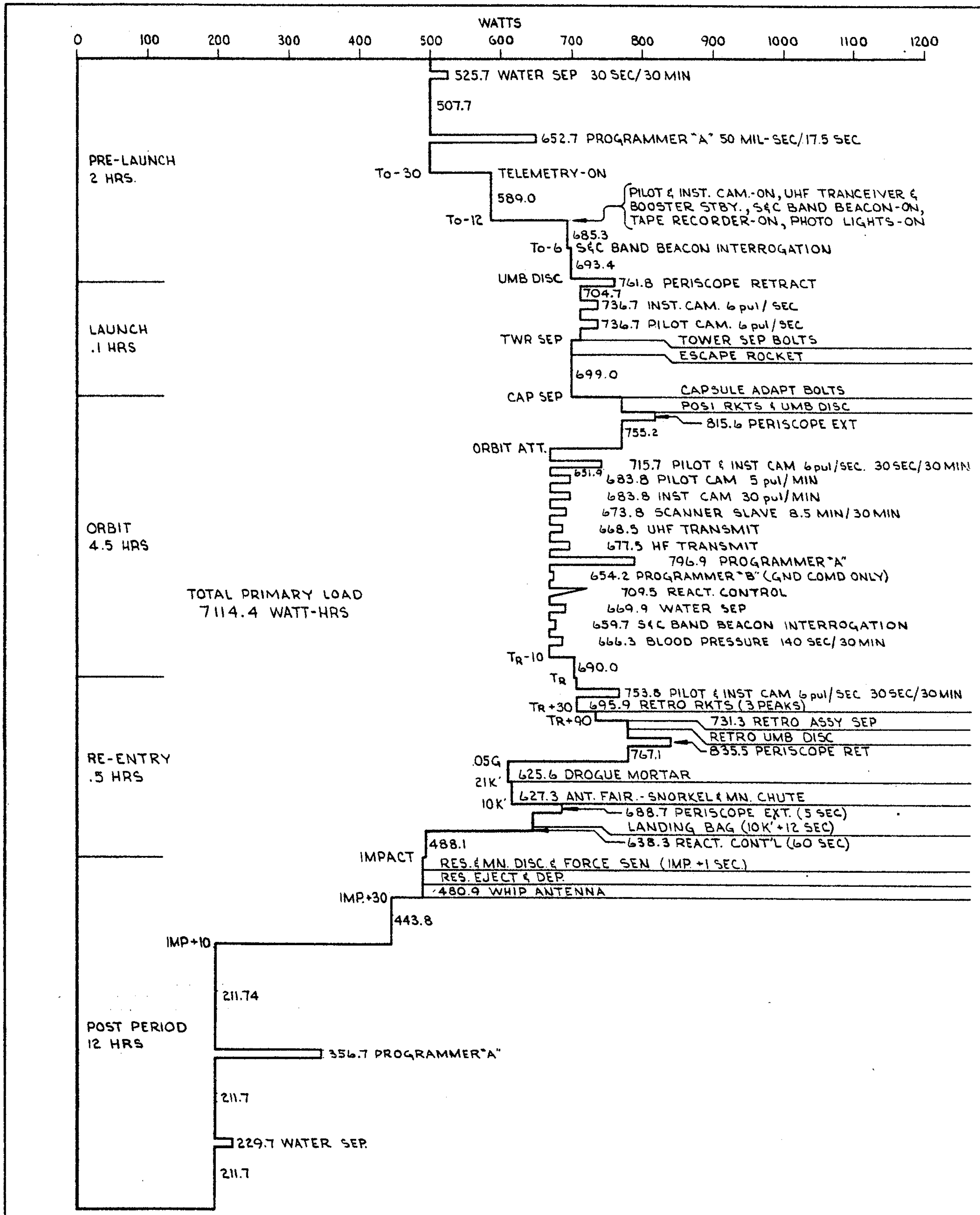


FIGURE 10-13 D-C WATT-HOUR LOADING (CAPSULE 13)

PM45-273

rating of four watts each. (See Figure 10-15).

10-37. Photo Flood Lights

Two flourescent flood lights are mounted on brackets to the left and right of the cabin flood lights described in Paragraph 10-35. The photo flood lights are identical to the cabin flood lights and are controlled by a PHOTO LIGHTS switch, which has an ON and OFF position. The PHOTO LIGHTS switch is mounted on the left console.

10-38. Warning Telelights

Warning telelights are provided for various capsule systems and are mounted on the main instrument and left console panels as shown on Figure 10-14. The telelights are connected to the various systems to notify the Astronaut of malfunction of a particular system or verification of an individual function. Power for the telelights is supplied by the Capsule 12V d-c or 24V d-c bus through a five ampere fuse as shown on Figure 10-15. A Dim-Bright Switch is provided for daylight or dark operations.

10-39. TEST CONFIGURATION CAPSULES

The data contained in Paragraphs 10-34 through 10-38 applies to the Specification Capsule. Deviations from the data applicable to the Test Configuration Capsules are explained in the following paragraphs. If data is not presented for a particular item, then the item is the same as that used on the Specification Compliance Capsule.

10-40. TEST CONFIGURATION CAPSULE NO. 8

10-41. Cabin Flood Lights

The cabin flood lights on Capsule No. 8 is the same as the Specification Compliance Capsule, except the control switch on Capsule No. 8 has "ON-OFF" positions only. (Refer to Paragraph 10-43.) No photo flood lights are used on

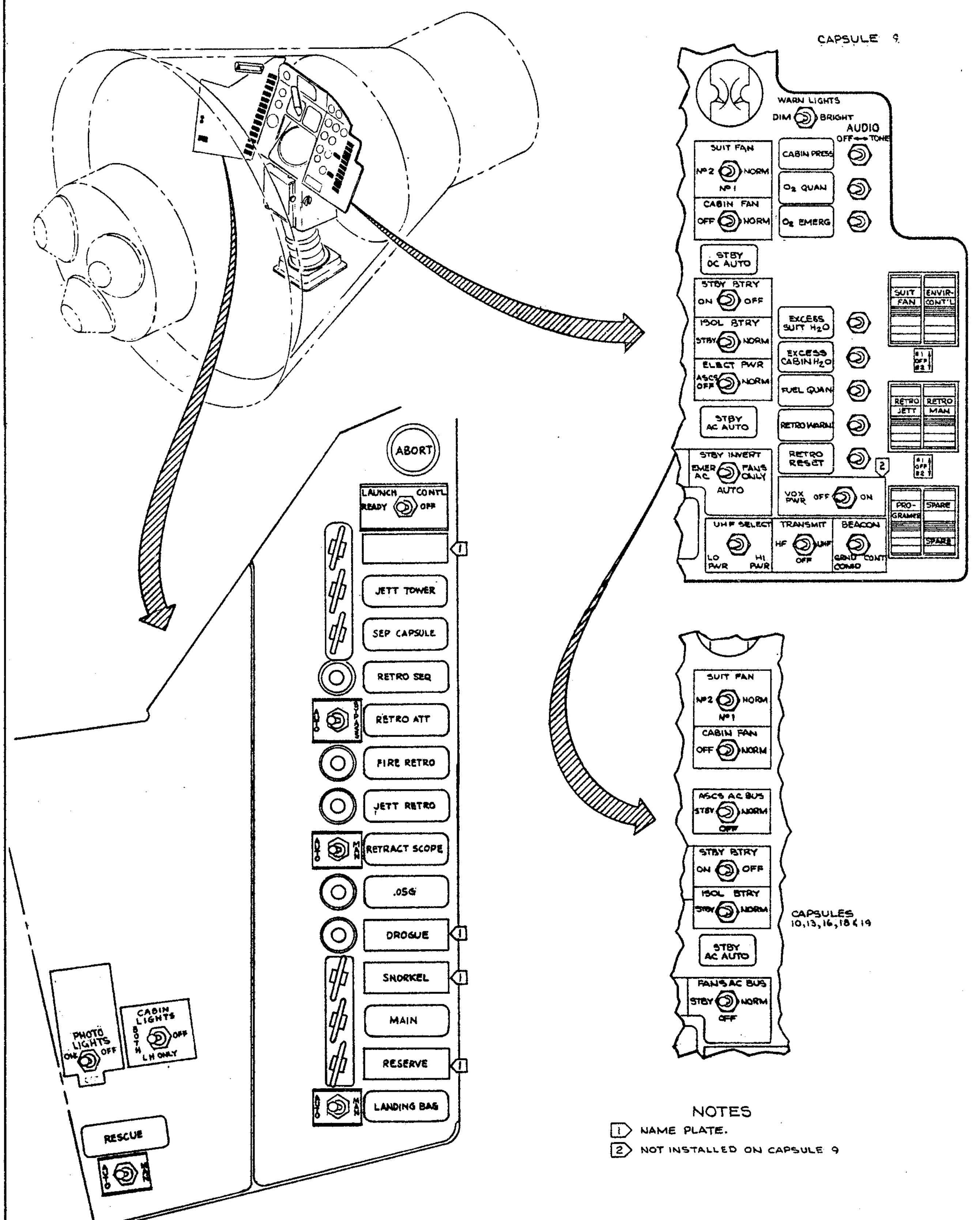


FIGURE 10-14 INTERIOR LIGHTING AND WARNING LIGHTS SYSTEM (CAPS 9, 10, 13, 16, 18 & 19) PM45-181E

Capsule No. 8.

10-42. Warning Telelights

The warning telelight installation on Capsule No. 8 is the same as the Specification Compliance Capsule (Refer to Paragraph 10-38 and Figure 10-16), except for the following differences.

(a) The Periscope retract telelight is not used on Capsule No. 8.

(b) The Landing Bag telelight is not used on Capsule No. 8.

(c) A Drogue Chute telelight is used on Capsule No. 8.

(d) The Cabin Pressure telelight is not used on Capsule No. 8.

(e) The Fuel Quantity telelight is not used on Capsule No. 8.

(f) Mayday and Ready telelights are used on Capsule No. 8 in place of the abort lights.

(g) A recording telelight is used on Capsule No. 8 to indicate operation of the tape recorder.

(h) A Standby d-c Auto telelight is used on Capsule No. 8.

10-43. TEST CONFIGURATION CAPSULES NO. 9, 10, 13 AND 16

The interior lighting system on these Capsules is the same as the Specification Compliance Capsule (Refer to Paragraphs 10-35 through 10-38) (See Figure 10-14 and 10-15).

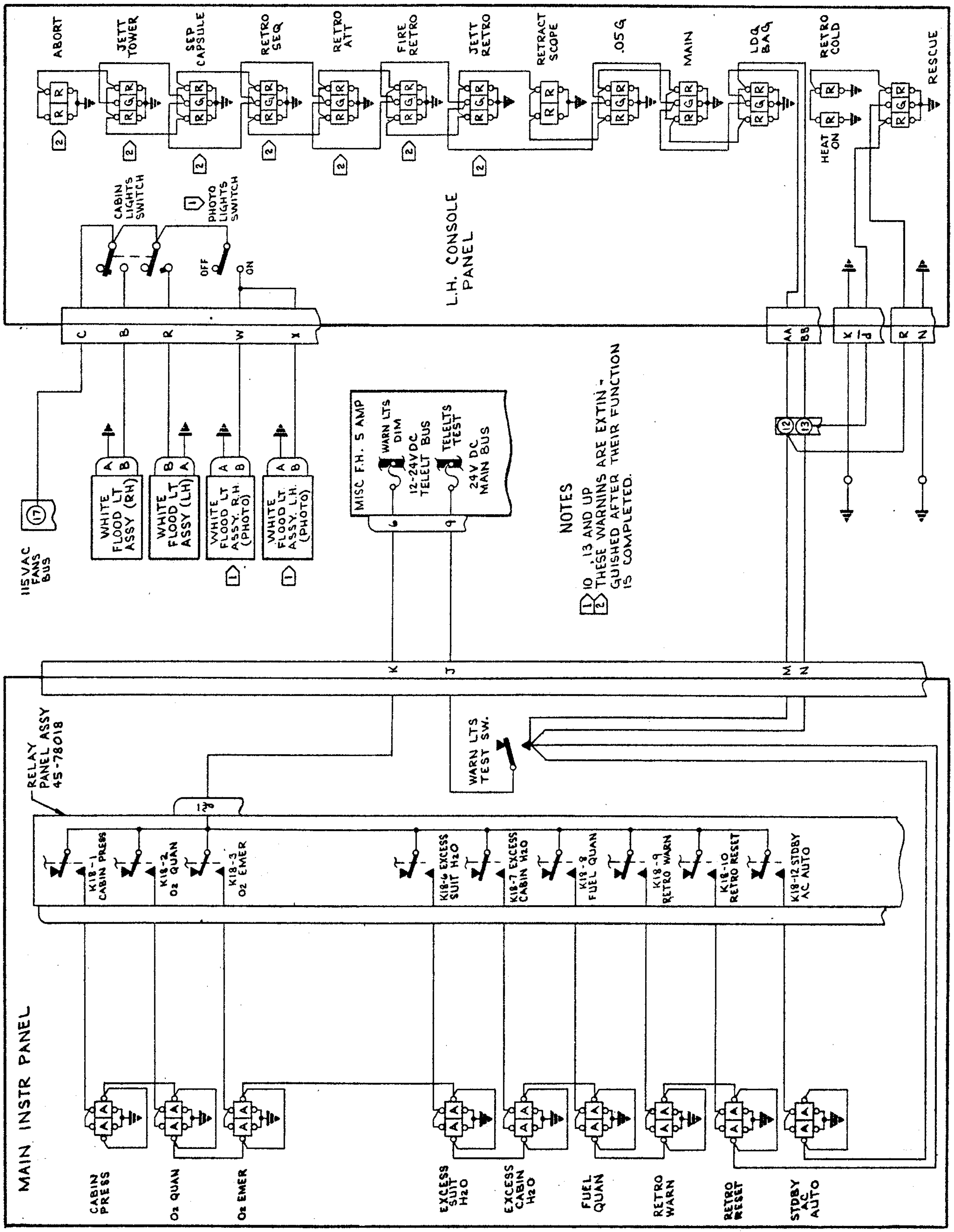


FIGURE 10-15 INTERIOR LIGHTS AND WARNING LIGHTS SCHEMATIC (CAPS. 9, 10, 13, 16, 18 AND 19) PM45-217D

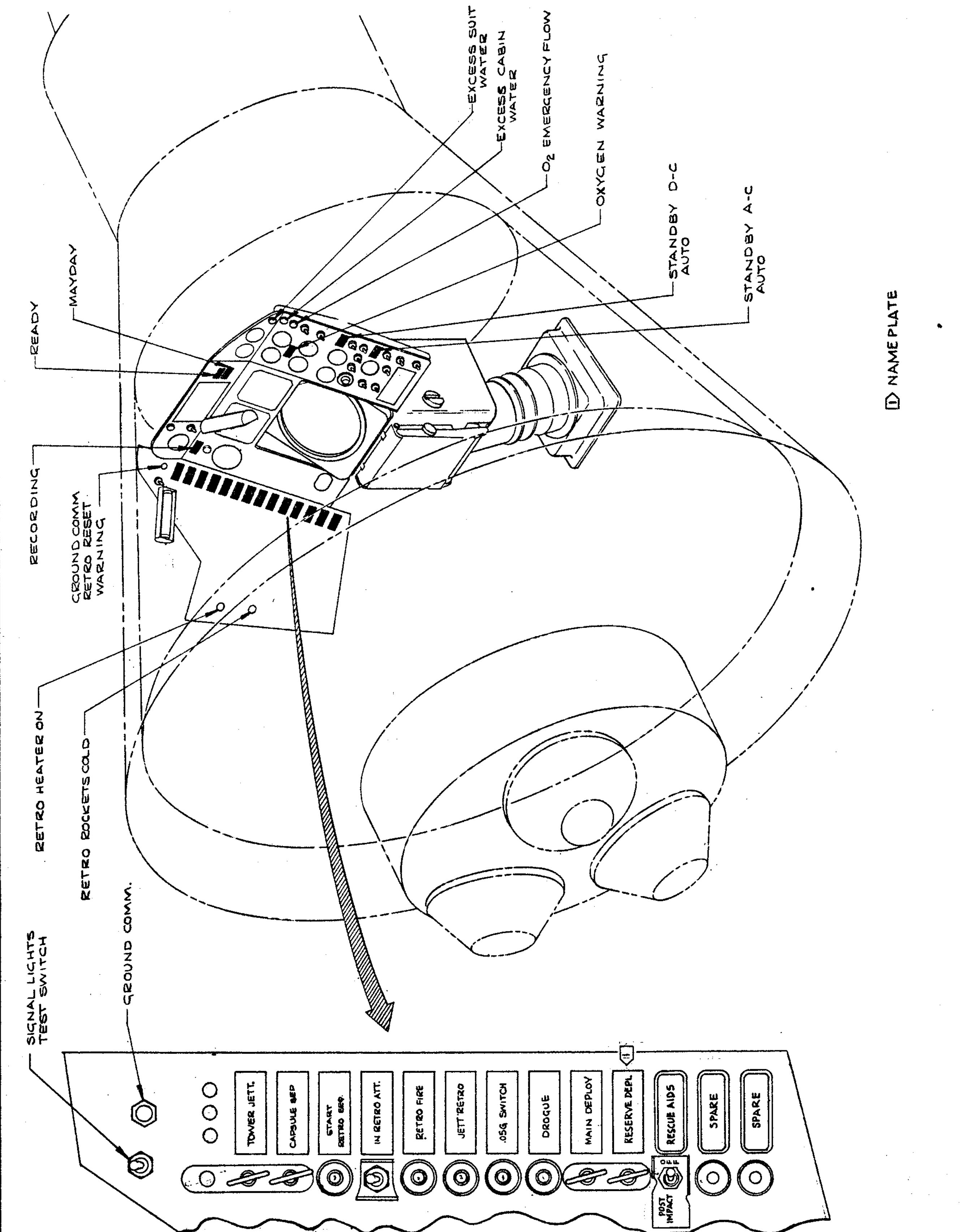


FIGURE 10-16 INTERIOR LIGHTS AND WARNING LIGHTS (CAPSULE 8)

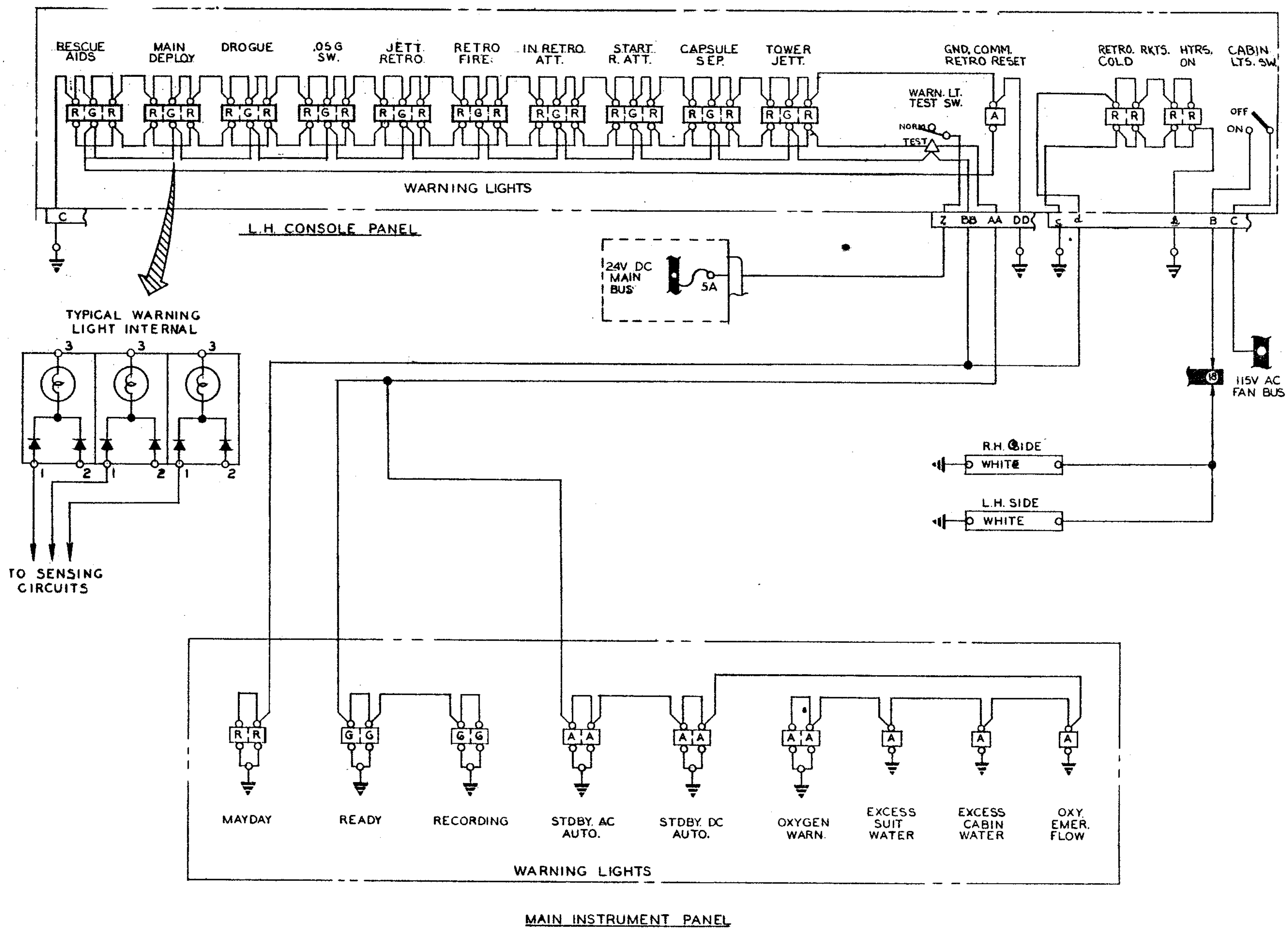
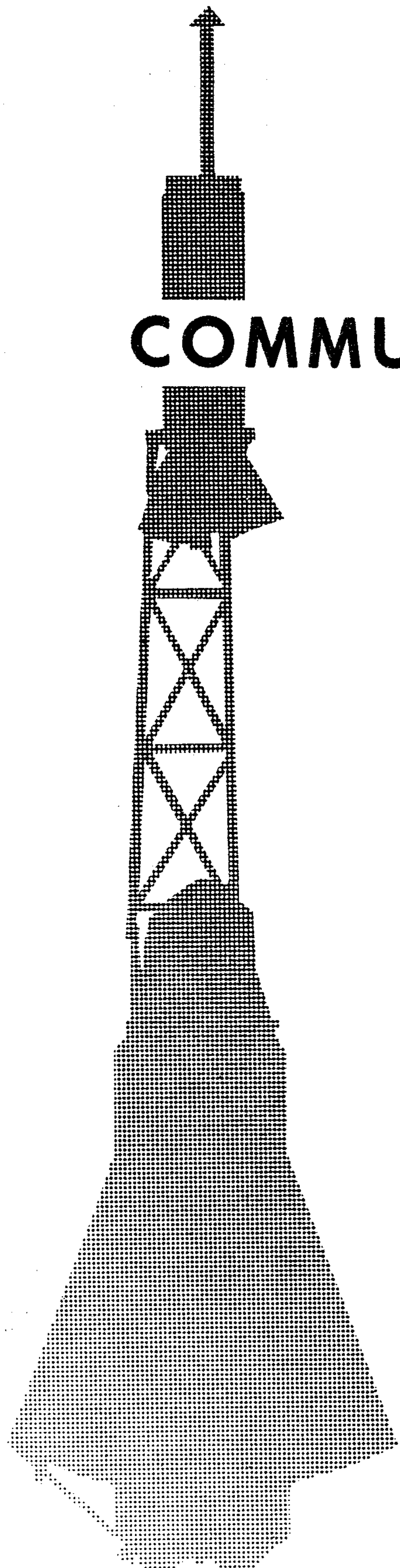


FIGURE 10-12 INTERIOR LIGHTS AND WARNING LIGHTS SCHEMATIC (CAPS. 8)

SECTION XI



COMMUNICATION SYSTEM

TABLE OF CONTENTS

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI
~~CONFIDENTIAL~~

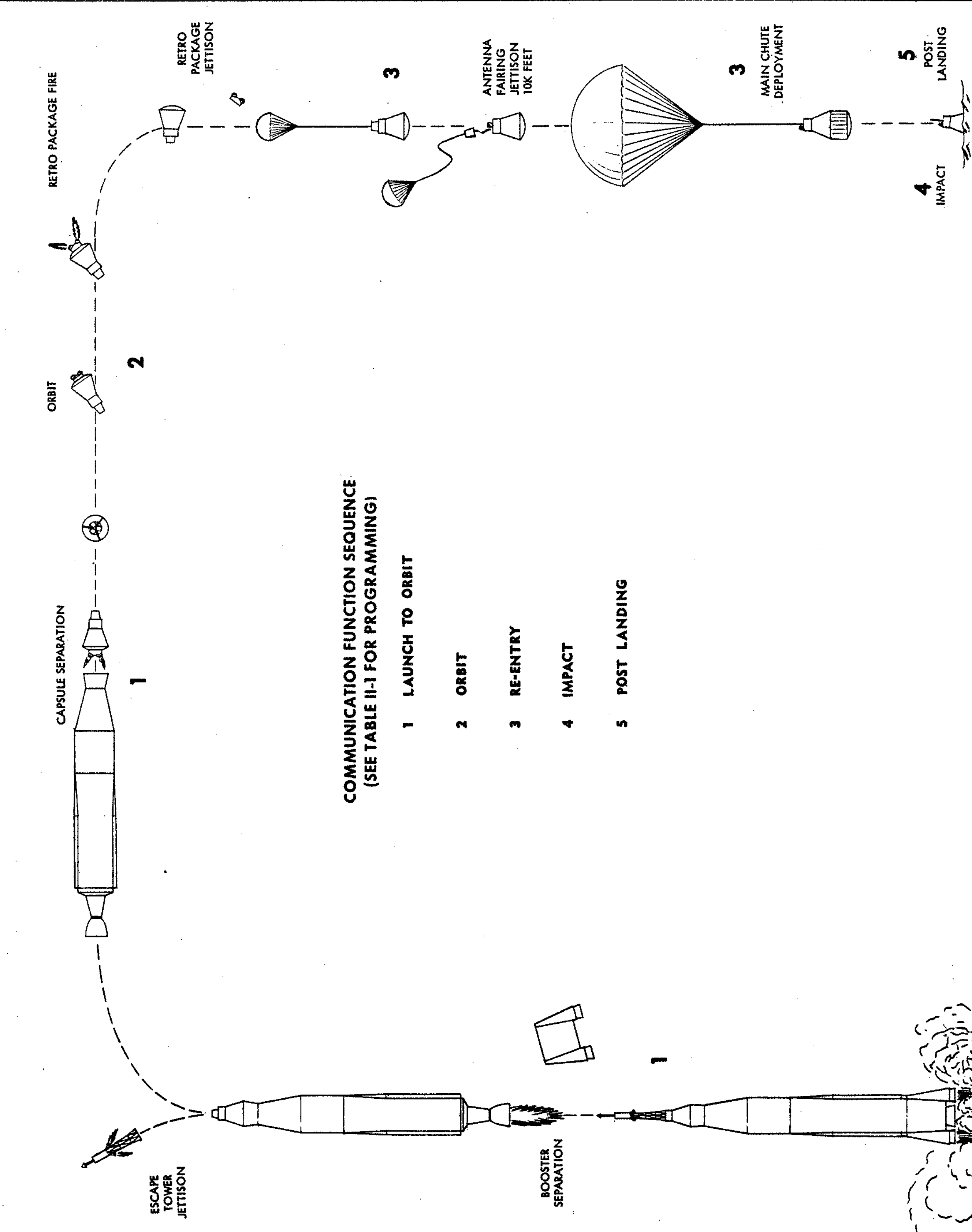


FIGURE 11-1 COMMUNICATION SEQUENCE

PM45-109E

~~CONFIDENTIAL~~

CONFIDENTIAL

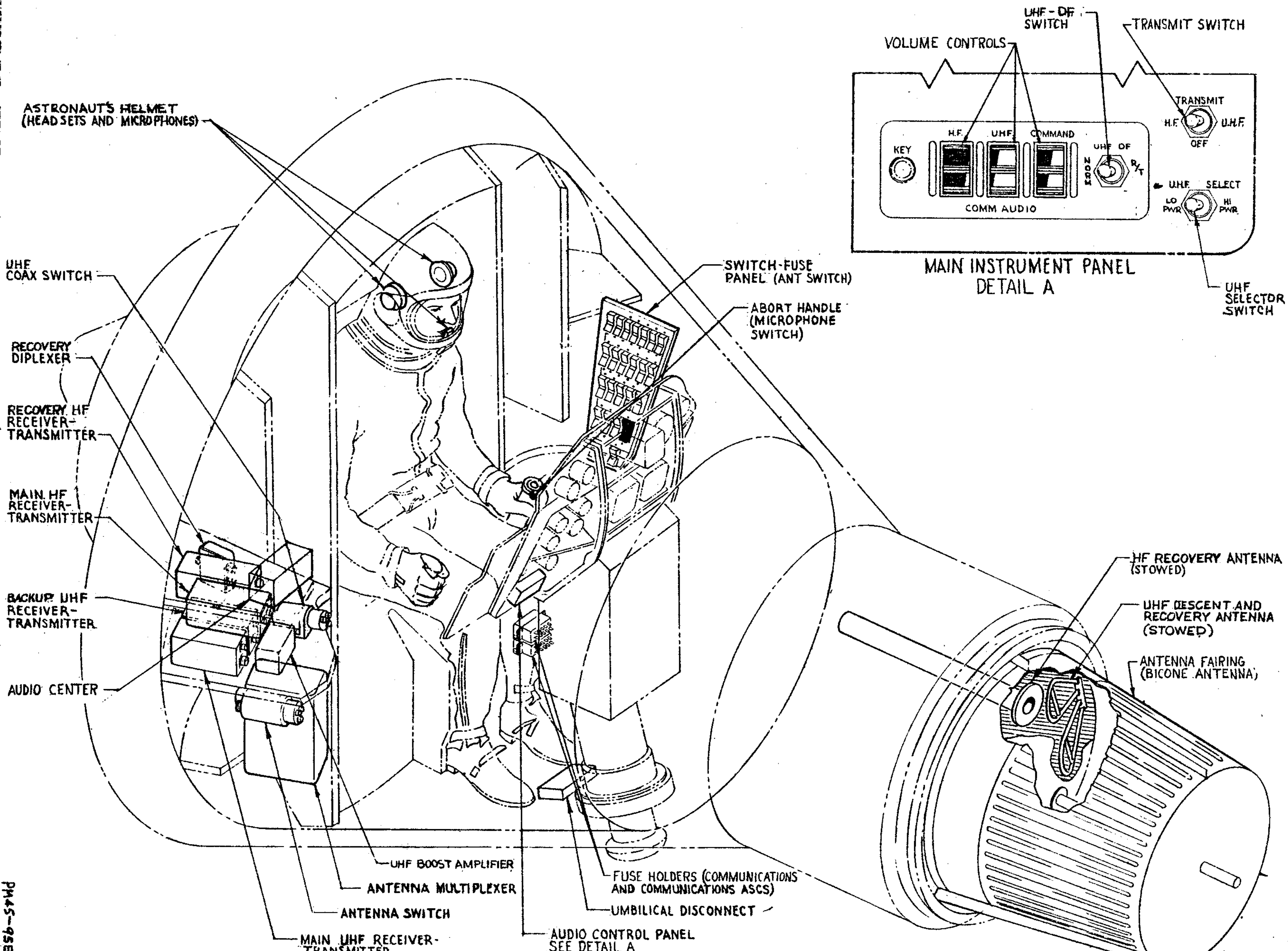


FIGURE 11-2 VOICE COMMUNICATIONS SYSTEM (CAPSULES 10,13,16,18,19)

CONFIDENTIAL

PM45-95E

TABLE 11-1
COMMUNICATION FUNCTIONS
(ALL CAPSULES)

FUNCTION	PHASE: LAUNCH	ORBIT	RE-ENTRY	IMPACT	POST LANDING
UHF (Main Backup) R/T	← Astronaut Selection on All Manned Capsules				→
UHF (Main Backup) R/T	← Pre-Launch Selection on All Unmanned Capsules				→
HF (Main) R/T	← Astronaut Selection on Manned Capsules		→		
HF (Main) R/T	← Pre-Launch Selection on Unmanned Capsules		→		
HF (Recovery) R/T				← All Capsules	→
Command Receivers	← All Capsules		→		
Telemetry Transmitter	← All Capsules		→	10 Minutes After Impact	
C and S Band Beacons	← Manned Capsules - On Continuous or Controlled by Astronaut and/or Ground Command		→		
C and S Band Beacons	← Unmanned Capsules - On Continuous or Controlled by Ground Command		→		
UHF Recovery Beacon	Bicone Ant. Separation		← All Capsules		→
H.F. Recovery Beacon				← All Capsules	→
Aux. UHF Rescue Beacon			10 Minutes After Impact	← Capsules 10,13,16,18 and 19	→
Ultr. Sarah Rescue Beacon	Bicone Ant. Separation		← Capsule 8 & 9 only		→

Unmanned Capsules - No.'s 8, 9
Manned Capsules - No.'s 10, 13, 16, 18 & 19

XI. COMMUNICATIONS SYSTEM

11-1. SYSTEM DESCRIPTION

11-2. VOICE COMMUNICATION

The Astronaut is provided with voice communications throughout the entire mission (See Table 11-1). A dual headset and microphone contained within the Astronaut's helmet, operate through the audio control circuits to the selected voice communications set (See Figure 12-2). A capsule-pad interphone system is available prior to umbilical cable disconnect.

HF reception is available through the main HF voice communication set during launch and orbit. HF voice transmission may be used only after capsule separation by Astronaut selection of the HF position of the Transmit Switch. The main set is disabled during re-entry as the antenna fairing is jettisoned. It will be de-energized and replaced by the recovery HF set upon landing. The recovery HF voice communications set provides reception and transmission, during the post landing phase of the mission.

UHF reception is available throughout the entire mission by the Comm. UHF voice communications set and its UHF Booster Amplifier. Transmissions over this set may be made when the "UHF" position of the TRANSMIT switch is selected by the Astronaut. A backup (low power) UHF voice communication set identical to the main set, but without the UHF Booster Amplifier, may be placed in operation by the Astronaut at any point during the mission.

The selected transmitter may be energized by operation of a push-to-talk switch, or by a voice operated relay when the VOX switch is in the "ON" position. By speaking into the microphone, the selected transmitter is automatically energized. Normally the selected UHF transmitter will automatically be energized upon landing to provide a direction finder signal. This automatic feature may be

CONFIDENTIAL

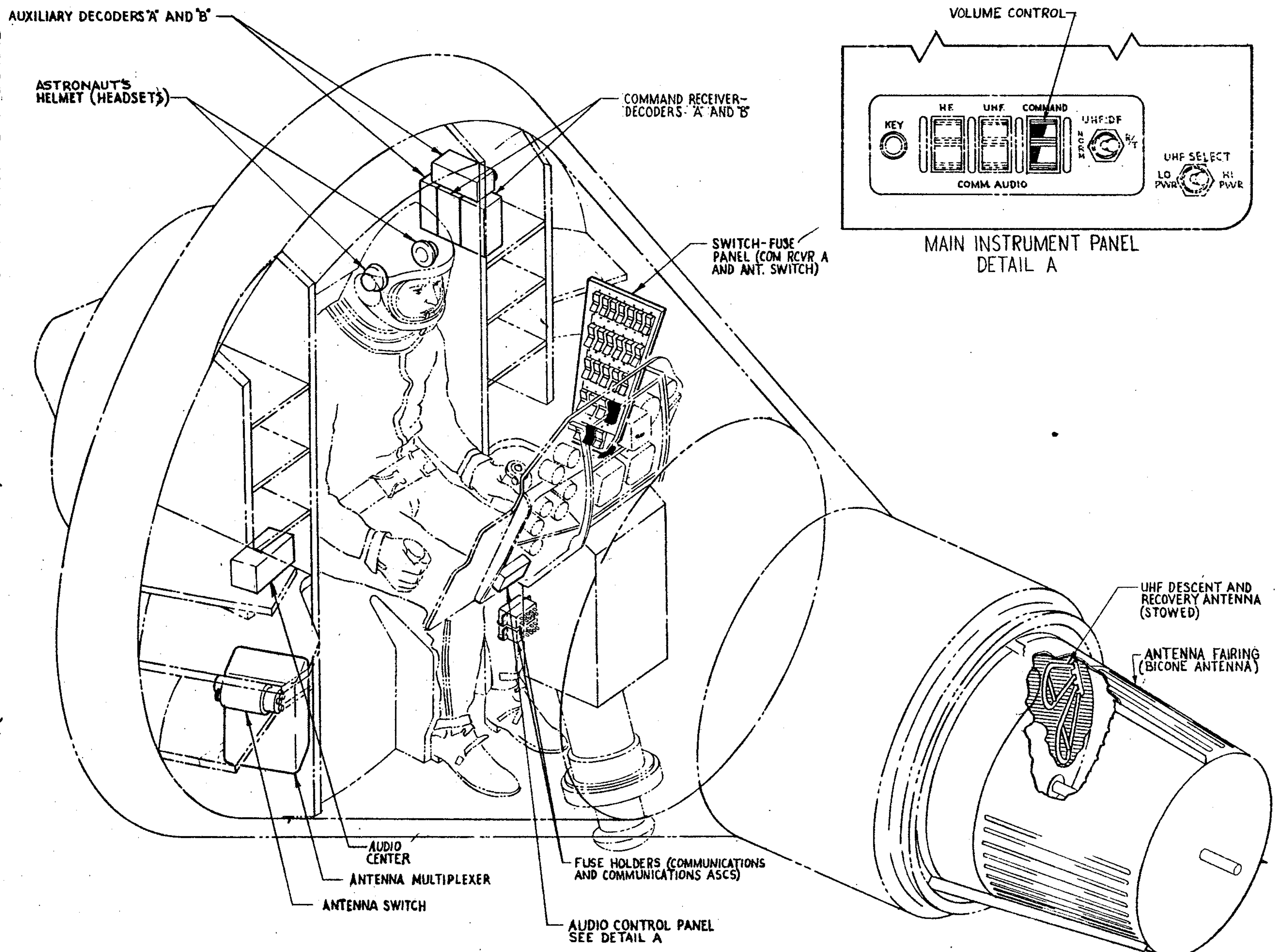


FIGURE 11-3 COMMAND RECEIVERS SYSTEM (CAPSULES 10, 13, 16, 18, 19)

PM45-97C

CONFIDENTIAL

overridden by the Astronaut.

The Command Receivers provide an emergency ground station-to-capsule voice communications channel throughout the mission until capsule impact. Power for the voice communications systems is supplied through fuses located in the Communications and Communications ASCS fuse holders (See Figure 11-2).

11-3. COMMAND RECEIVERS

Two separate sets of receiver-decoder and auxiliary decoder units are used for reception and decoding of ground command signals. These signals are for the purpose of activating various capsule control circuits.

Power for the command receivers is supplied through the fuses located in the Communications and the Communications ASCS Fuse Holders (See Figure 11-10).

11-4. TELEMETRY

Telemetry transmitters are provided for communicating capsule information to ground stations. Information is picked up throughout the capsule in the form of voltages from voltage divider circuits. These voltages are modified by coding circuits to supply suitable inputs to the telemetry transmitters. (Refer to the Instrumentation Section XIII of this manual). Two transmitters are used for transmission of the telemetry information, each having a power output of 3.3 watts. Their frequencies are slightly separated. Transmitters are operated continuously from launch, until 10 minutes after impact. The power outputs of the telemetry transmitters are fed to either the main or the UHF Recovery Antenna. Power for the system is obtained from fuses located in the Instrumentation Fuse Holders (See Figure 11-4 and Figure 11-11).

11-5. BEACONS

The beacons provided in the capsule to aid tracking by ground stations are a C-Band and an S-Band beacon, a UHF recovery beacon, energized during re-entry,

CONFIDENTIAL

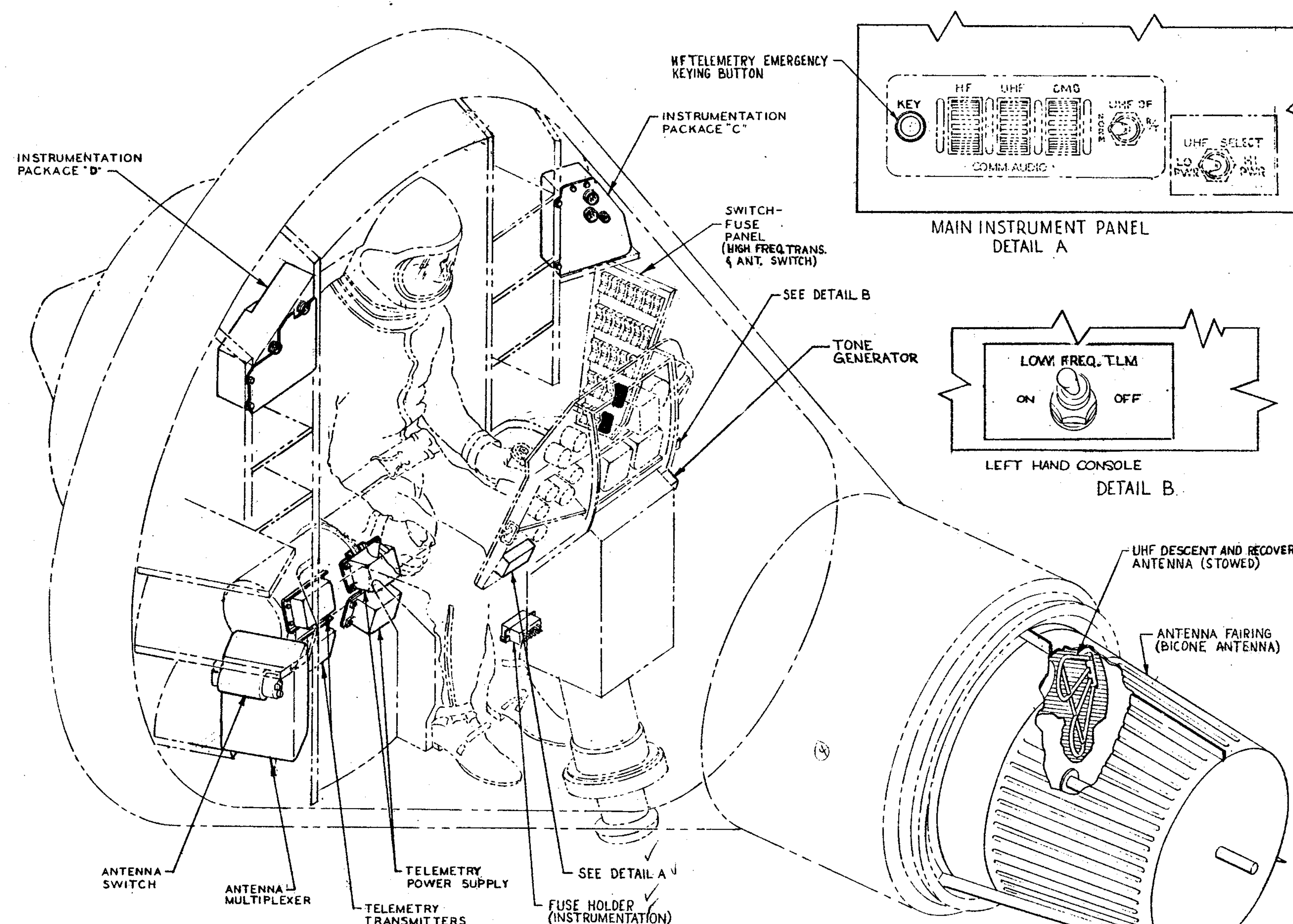


FIGURE 11-4. TELEMETRY SYSTEM (CAPSULES 10, 13, 16, 18, 19)

PM45-99B

CONFIDENTIAL

an aux. UHF beacon energized 10 min. after impact, and an HF recovery beacon, energized upon landing. These beacons provide signals compatible with direction finding equipment used by the recovery crews. The UHF voice communications transmitter may be keyed upon landing to provide an additional signal for direction finders. A flashing light is installed for visual location of the capsule after landing. (See Section IX of this manual.)

Capsule power for the beacons system is supplied through fuses located in the communications and ASCS fuse holders. (See Figures 11-5 and 11-12).

11-6. ANTENNAS

The voice communications, telemetry and beacon receivers and transmitters, with their various frequencies and types of outputs require an antenna system with wide capabilities. Therefore, four types of antennas are used to fulfill the entire mission requirements. A main HF-UHF antenna is used for the major portion of the mission. During re-entry this antenna must be jettisoned to allow main parachute deployment. To replace the UHF function, a compact UHF antenna is automatically placed in operation. Upon landing, an HF Recovery Antenna is extended to permit HF operation. Throughout the entire mission, C and S band antennas are provided for operation of the radar beacons. Antenna switching and multiplexing are performed automatically by the RF circuitry. (See Figures 11-6 and 11-13). Power requirements for antenna switching are supplied through a switch-fuse located on the left console switch-fuse panel. (See Figure 11-13).

11-7. SYSTEM OPERATION

11-8. VOICE COMMUNICATIONS

11-9. Audio Control and Ground Interphone System

HF and UHF receiver outputs are routed to the control panel. This panel

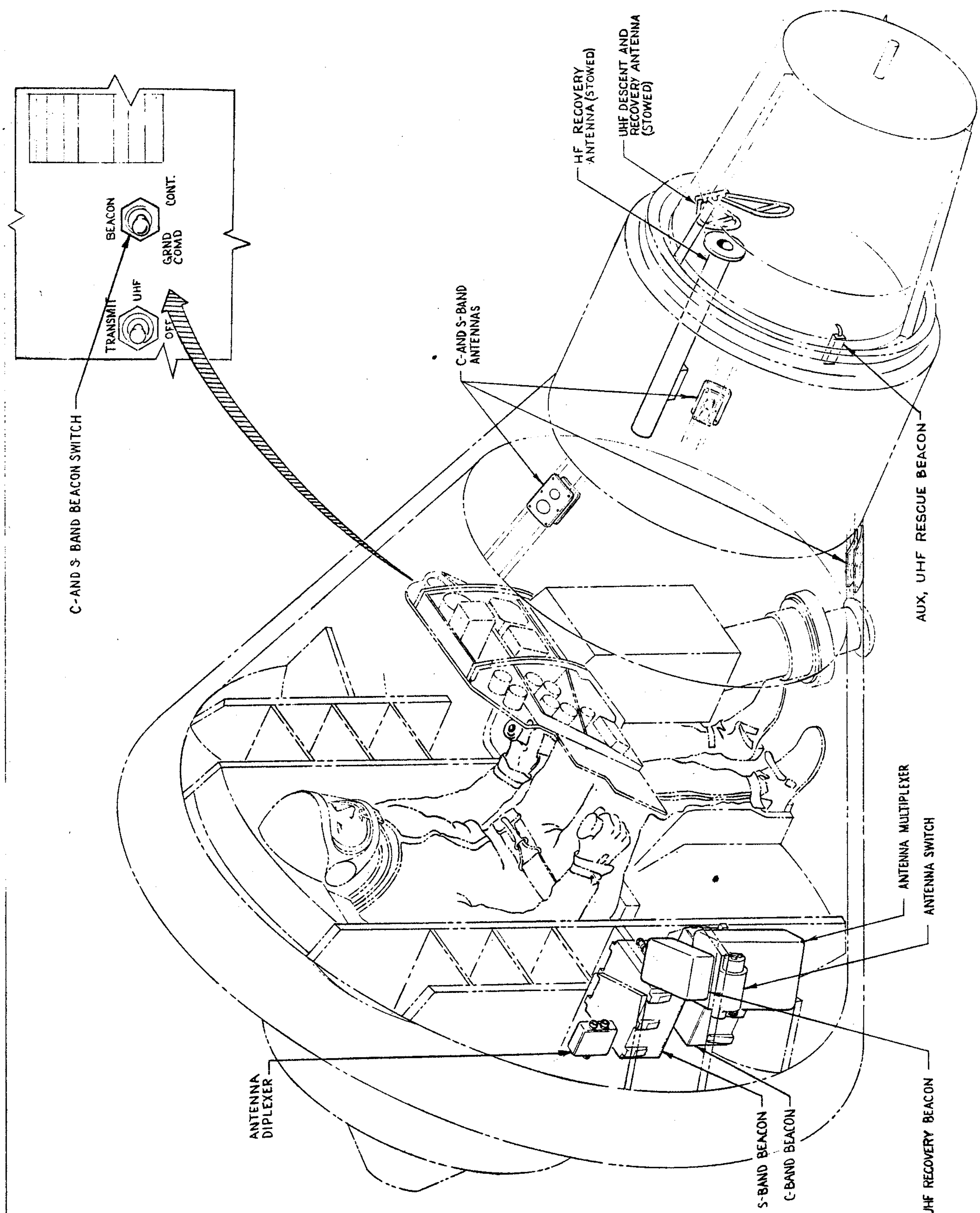


FIGURE 11-5 BEACONS SYSTEM (CAPSULES 10, 13, 16, 18, 19)

PM45-101B

provides one volume control for HF audio and one volume control for UHF audio. Outputs from the two command receivers are connected to the Communication Control Panel for mixing. Separation of command and voice audio signals by a low pass filter, and amplification of resulting voice audio is done in the control panel. (See Figure 11-7).

Communication audio signals from the volume controls, the interphone audio from the pad-to-the-pilot and alarm tones from the satellite clock are supplied to the tape recorder relay and the two headset amplifiers in the audio center. The headset amplifiers serve to amplify the audio signals and feed them to the individual earphones in the Astronaut's helmet. The de-energized position of the tape recorder relay supplies a path for receiver audio to the main tape recorder.

Audio from the microphones is fed to two separate microphone amplifiers in the audio center. These two amplifiers serve to amplify microphone output to a level sufficient to supply modulation circuits of the voice transmitters. The microphone amplifer output is also fed to the input of the VOX (voice operated relay circuitry). The voice circuits are energized by use of the Push to Talk switch on the abort handle, or by the VOX circuit when the VOX switch on the instrument panel is in the "ON" position.

11-10. <u>HF Voice Communications</u>

11-11. Main HF Communications

The main HF voice communications set is an AM receiver-transmitter unit designed to operate on a frequency of approximately 15 MC.

Power from the main pre-impact 24 volt d-c bus is fed directly to the receiver section of the set. The transmitter is fed 24 volts through the HF position of the Transmit Switch and the closed contacts of the tower separation relay, after tower separation. Audio input to the transmitter portion of the

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

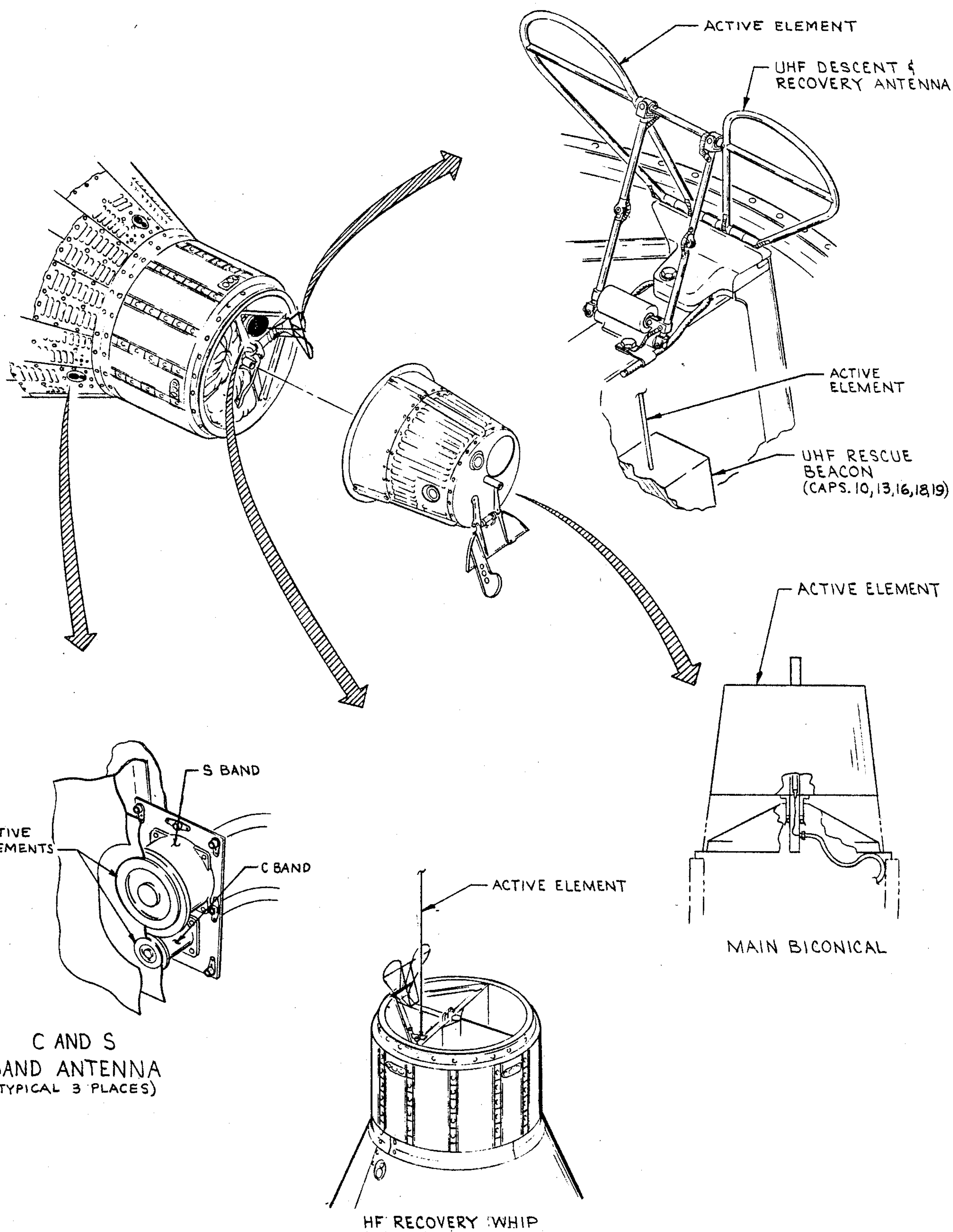


FIGURE 11-6 ANTENNA SYSTEM UTILIZATION (ALL CAPSULES)

PM45-107D

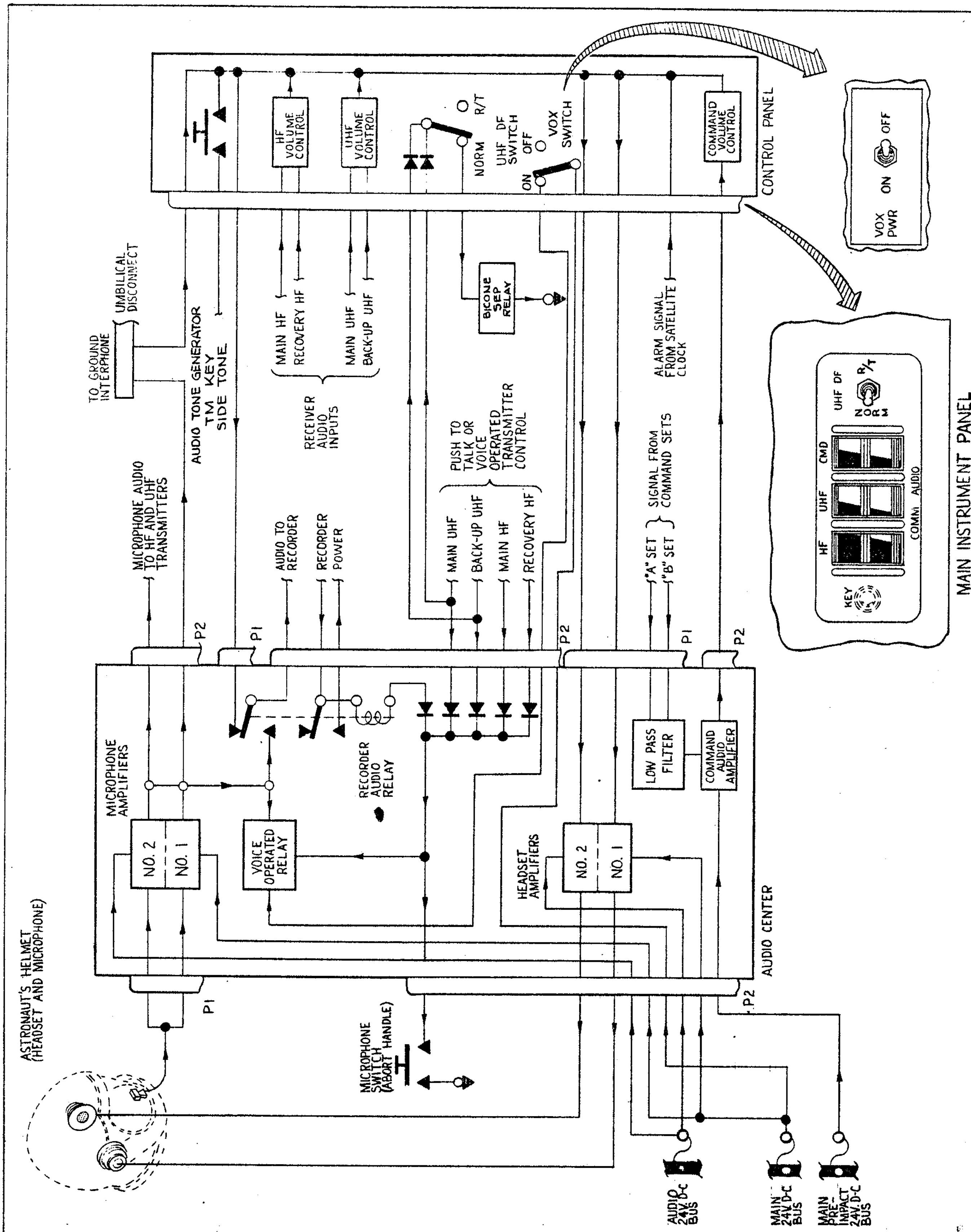


FIGURE 11-7 AUDIO CONTROL AND GROUND INTERPHONE SYSTEM (CAPS. 10, 15, 16, 18, 19)

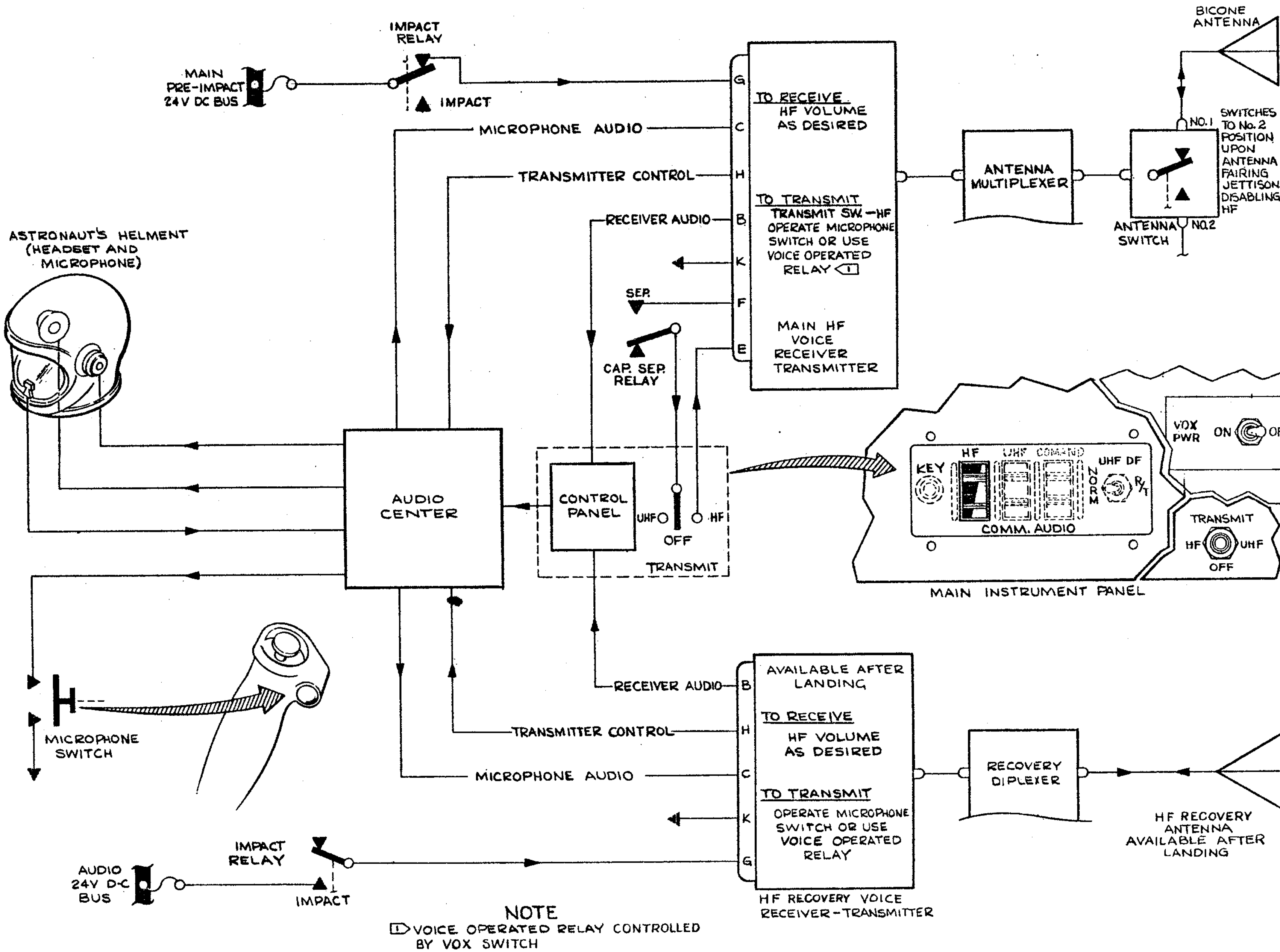


FIGURE 11-8 HF COMMUNICATIONS DATA FLOW (CAPS. 10, 13, 16, 18 & 19)

unit is from the microphone amplifier in the audio center. The transmitter is energized either automatically through the VOX circuit or manually by the Astronaut's use of the push to talk switch. (See Figure 11-8).

The antenna connection from the set is through the antenna multiplexer and the antenna switch to either the bicone or the UHF Rescue antenna. HF radiation from the descent antenna is negligible. Audio output from the receiver, including sidetone during transmission is routed to the HF volume control in the control panel.

11-12. Recovery HF Communications

The recovery HF voice communications set is basically the same as the main HF unit but with the transmitter having a lower output.

The power input to the recovery HF unit is supplied upon landing, through the impact relay, from the audio 24 volt d-c bus. Audio is supplied and keying of the transmitter is in the same manner as the main set.

The antenna connection is through the recovery diplexer to the extended HF Rescue antenna. Audio output from the receiver, including sidetone, is routed through the HF volume control in the control panel through the audio center and to the headsets.

11-13. UHF Voice Communications

11-14. Main UHF

The main UHF voice communications set is an AM receiver-transmitter unit designed to operate on a frequency of approximately 299 MC. The transmitter output is increased by a separate UHF booster amplifier.

Power from the audio 24 volt d-c bus is fed through the HI-PWR position of the UHF Selector Switch directly to the receiver section of the set. (See Figure 11-9). This power is also fed to the Transmit Switch. Power for the transmitter section of the set is then taken from the UHF position of the

Transmit Switch. At bicone antenna separation the bicone separation relay contacts assume the same function as the UHF contacts of the Transmit Switch thus providing a continuous UHF signal for DF purposes. Audio input to the transmitter portion of the unit is from the microphone amplifers in the audio center. The transmitter is energized either automatically or manually by the Astronaut. When the HI-POWER set is selected with the UHF Selector Switch, it will be energized automatically at bicone separation to provide a UHF signal for direction finding equipment. This feature may be overriden by operation of the UHF DF Switch on the control panel to the OFF or the UHF position.

Antenna connection from the set is through the UHF booster amplifer coax switch, antenna multiplexer, and the antenna switch to either the main bicone or UHF rescue antenna. Operation of the microphone switch or energizing the voice operated relay while in the UHF mode causes the booster amplifier to be inserted in series with the coax line. Transmitter output is then boosted by this amplifier to 2 watts. The booster is also available after landing. The multiplexer output is connected through the antenna switch to either the main bicone or the UHF rescue antenna. Audio output from the receiver, including sidetone during transmission, is routed to the UHF volume control in the control panel.

11-15. Backup UHF

The Lo power UHF voice communications set is identical to the main set but without the booster amplifier. It may be energized by Astronaut operation of the UHF Selector Switch to the "LO PWR" position. Power input, audio input, receiver output, and the control of the transmitter is in the same manner as used for the main UHF set.

Antenna connection is routed through the UHF coax switch, which has been energized by selecting the "LO POWER" position of the UHF Selector Switch, through

CONFIDENTIAL

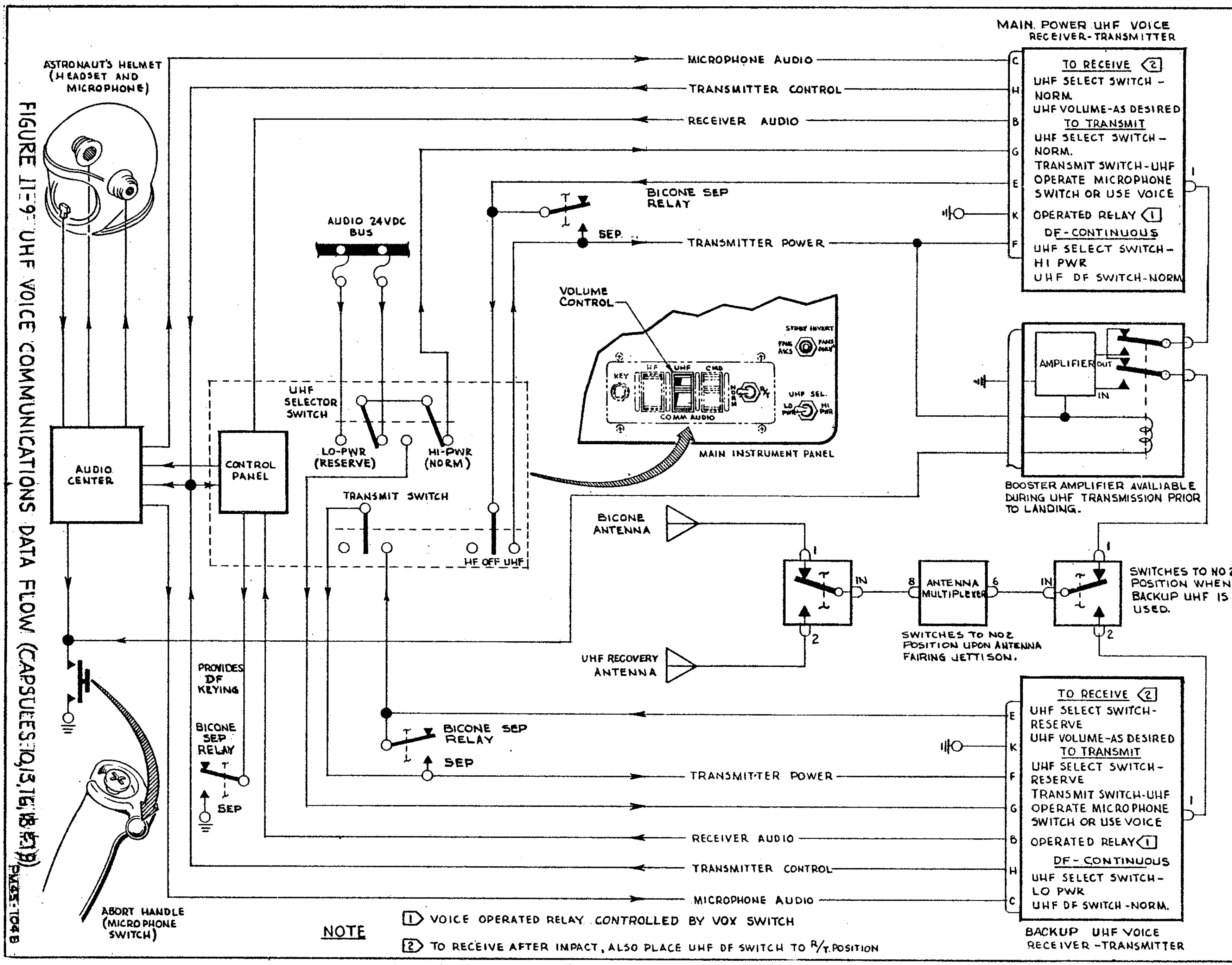


FIGURE 11-9 UHF VOICE COMMUNICATIONS DATA FLOW (CAPSULES 10,13,16,18,19)

P45-104B

CONFIDENTIAL

the UHF booster's coax switch, the antenna multiplexer and the antenna switch to either the main bicone or UHF rescue antenna.

11-16. Command Receivers

The receiver-decoder unit consists of an FM receiver operating in the frequency range of 406 to 450 MC. The received signal may be modulated with a maximum of six of a possible twenty audio frequencies. The receiver reduces the input signal to the modulation frequencies which operate individual control relays. (See Figure 11-10).

Each control relay provides contacts for a normally open or a normally closed control channel. Ten channels are provided in the "A" receiver-decoder with an additional ten available in the "A" auxiliary decoder. These channels are paralleled by the output of the "B" receiver-decoder, and auxiliary decoder units. Command channel assignments are not disclosed for security reasons. Emergency voice communications may be had from the ground station to the capsule through the command receivers. Receiver outputs are supplied through a filter and amplifier in the audio center circuits to the Astronaut's headset. Power for the Hi frequency command set is supplied from the isolated 18 volt d-c bus while power for the Lo frequency command set is supplied from the standby 18 volt d-c bus. Both power circuits are routed through sections of the impact relays in order to de-energize the set upon landing.

Antenna input is from the bicone or UHF rescue antenna through the antenna switch and antenna multiplexer to an impedance match which supplies both receivers.

11-17. Telemetry

11-18. Low Frequency Telemetry

The low frequency telemetry set is an FM transmitter operating on a frequency of approximately 228 MC.

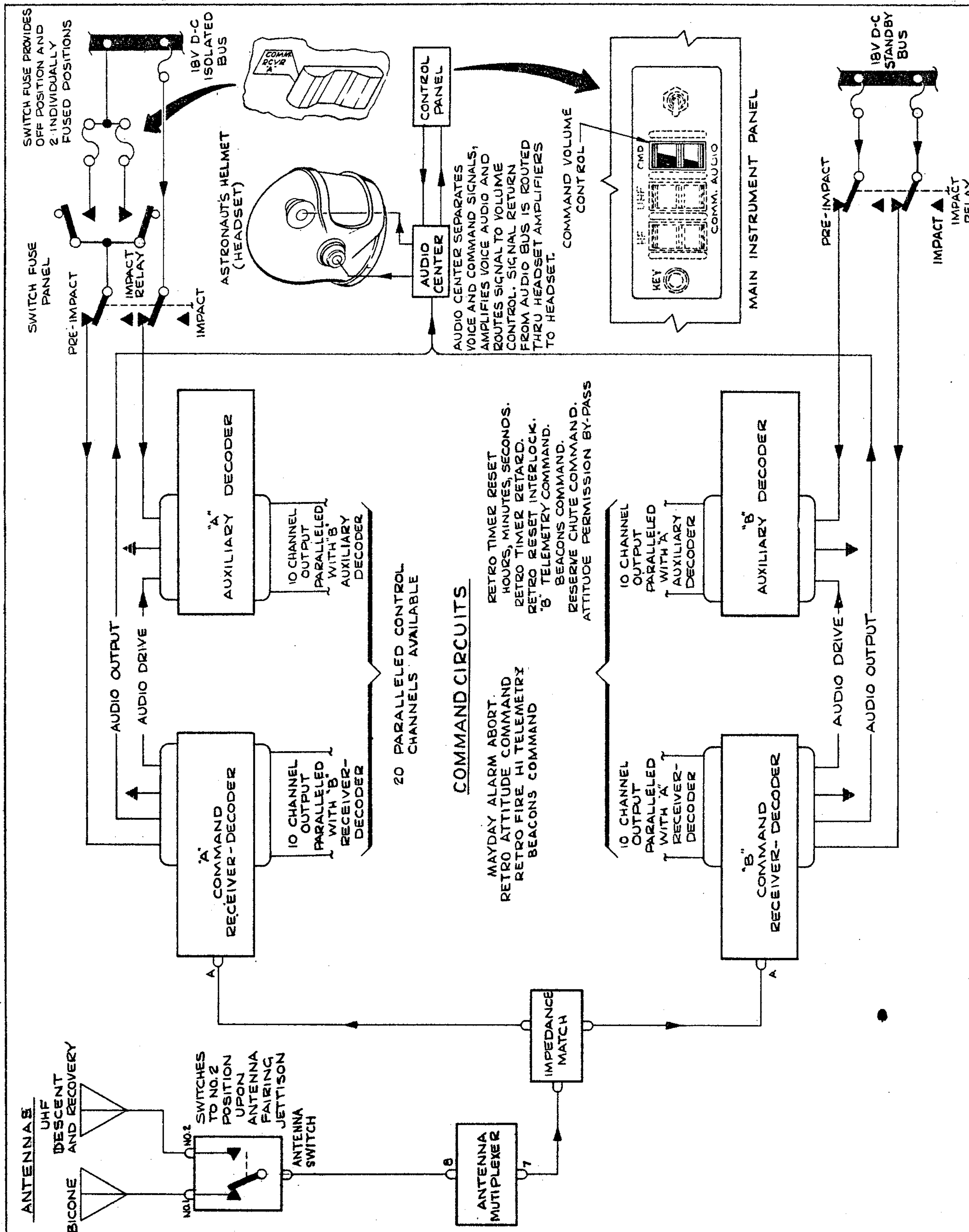


FIGURE 11-10 COMMAND RECEIVERS DATA FLOW (CAPSULES 10, 13, 16, 18 & 19)

PM45-98D

CONFIDENTIAL

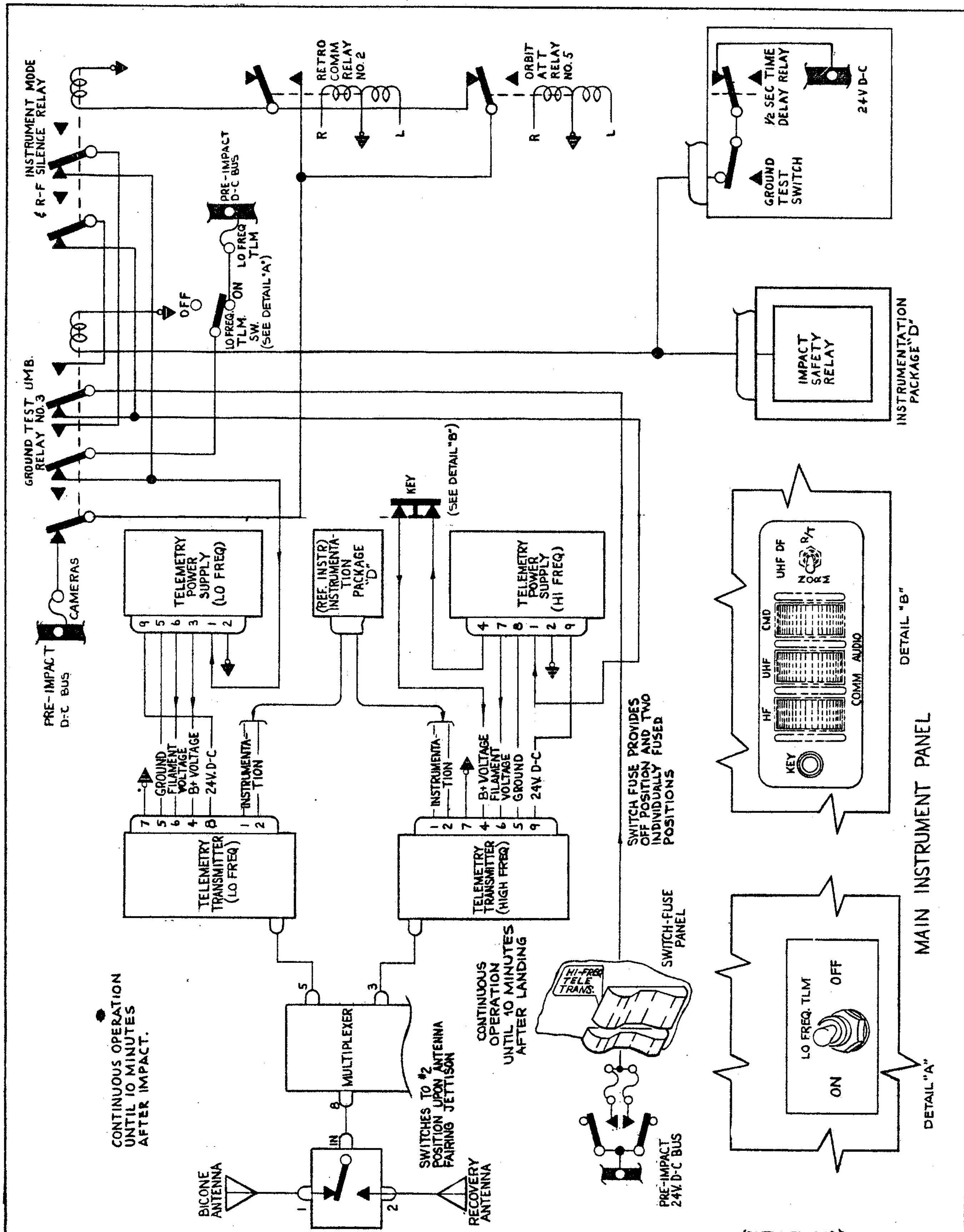


FIGURE 11-11 TELEMETRY SYSTEM DATA FLOW (CAPSULES 10, 13, 16, 18 AND 19 .....) PM45-100E

Before umbilical drop, the low frequency telemetry transmitter and its power supply receive 24 volts d-c from the Main Pre-impact bus through the energized Ground Test Umbilical Relay, normally open contacts. This relay's solenoid is energized through the umbilical until the umbilical is dropped. (See Figure 11-11).

To silence the TM transmitter, the solenoid of the Instrument Mode and R-F Silence relay may be energized through the following three methods. First by positioning the GROUND TEST switch in the block house to the "TEST" position, the Instrument Mode and R-F Silence Relay will be energized. By a second method the solenoid may be energized through the de-energized Orbit Attitude Relay, thus causing the silencing of the TM transmitters. The third method of energizing the Instrument Mode and R-F Silence Relay is through the normally open contacts of the energized Retro Command Relay #2. After the umbilical is dropped, the ground test umbilical relay is de-energized and power is directed through the closed contacts to the telemetry power supply. (See Figure 11-11). A LO FREQ. TLM, ON-OFF switch located on the left console, when in the "OFF" position, will break the power source to the LO FREQ. TM.

Coded instrumentation information is supplied from the instrumentation package "D", and used to frequency modulate the transmitter. (See the Instrumentation Section XIII of this manual).

RF power output is fed to the antenna multiplexer where it is routed through the antenna switch to the main bicone or UHF recovery antenna.

11-19. High Frequency Telemetry

The hi frequency telemetry set operates on a frequency of approximately 260 MC. The 24 volts d-c to the hi frequency telemetry is supplied by the same method as described under the low frequency telemetry description, with the exception that the ON-OFF switch provided in the capsule is in the form of a switch-fuse (HI FREQ.), located on the left hand switch-fuse panel. Input power for the set is from a separate telemetry power supply operating from the second pre-impact 24 volt d-c bus and supplying filament and B+ voltage. The B+ voltage supply is routed through the key on the control panel. This allows the Astronaut to interrupt the circuit transmitting code, in the event the voice communications fail. (See Figure 11-11).

Coded instrumentation information is supplied from the instrumentation package "D" to frequency modulate the transmitter. (See the Instrumentation Section XIII of this manual).

RF power output is fed to the antenna multiplexer where it is routed through the antenna switch to the main bicone or UHF recovery antenna.

11-20. Beacons

11-21. C-Band Beacon

The C-Band beacon is a transponder unit consisting of a receiver and transmitter operating on a frequency of approximately 5400 to 5900 MC. The beacon is double pulsed and is compatible with the FPS-16 radar when the ground units are modified for this type of operation. Upon ground command, through the command receivers, or by Astronaut selection of the "CONTIN." position of the Beacon Switch, the beacon receiver is energized. Interrogation by ground radar will then result in a coded reply from the beacon transmitter. Input power is from the main pre-impact 24 volt d-c bus through the beacon relay controlled by the command receivers, or, for continuous operation, through the Beacon Switch. (See Figure 11-12.)

Beacon antenna connection is through a phase shifter and the C-Band power divider to the three C and S band beacon antennas.

11-22. S-Band Beacon

The "S" Band Beacon is a transponder unit consisting of a receiver and trans-

CONFIDENTIAL

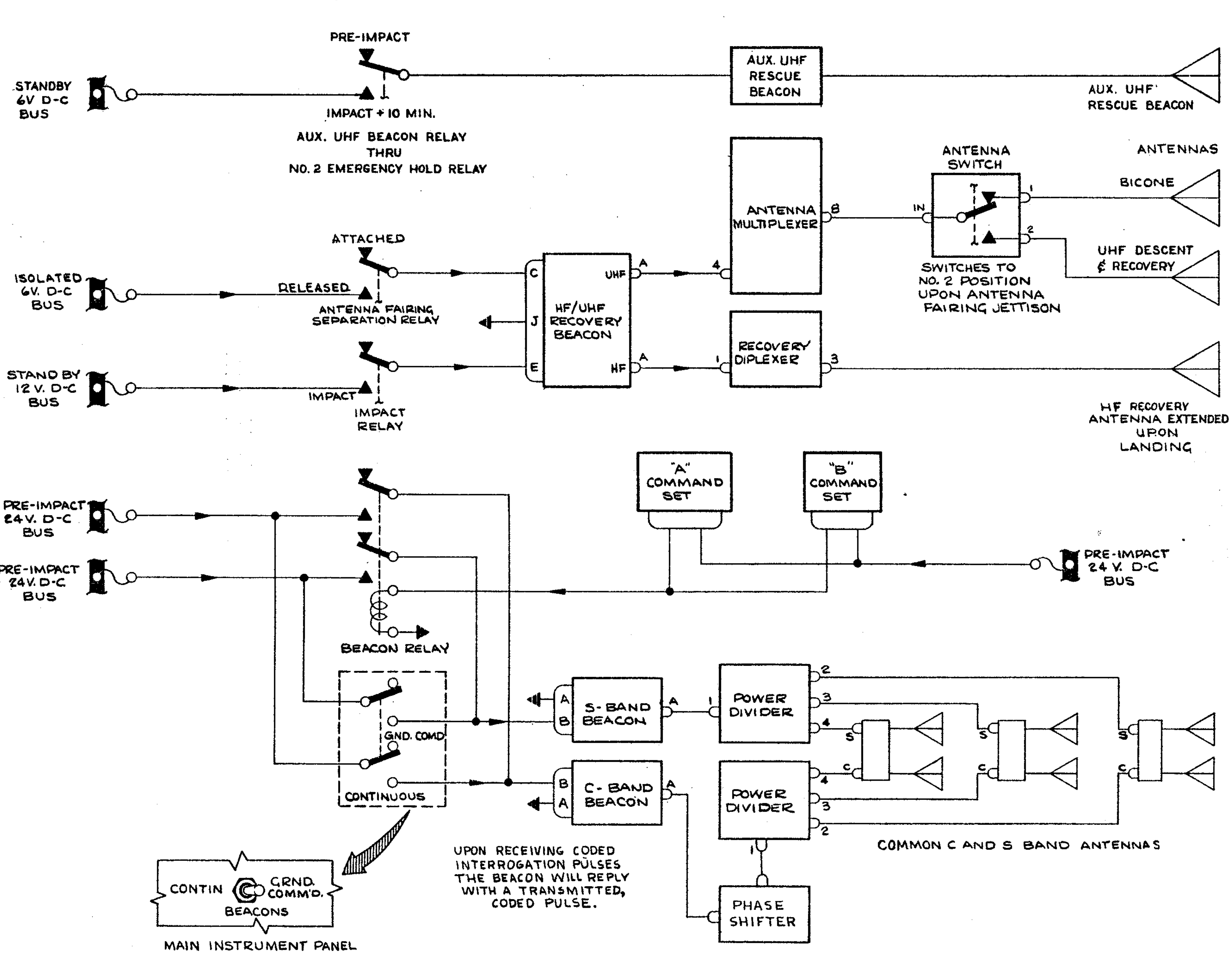


FIGURE 11-12 BEACONS SYSTEM DATA FLOW (CAPSULES 10, 13, 16, 18 & 19)

PM 45-108E

CONFIDENTIAL

mitter. (See Figure 11-12). The unit operates on a frequency of approximately 2700 to 2900 MC and is double pulsed to reduce possibilities of unauthorized interrogation. This unit is compatible with ground based Verlort Radars and operates at a positive acceptance tolerance of ± 0.5 micro-seconds and a positive rejection tolerance of ± 1.8 micro-seconds.

Power circuits, interrogation and reply are the same as the C-Band Beacon. (Refer to paragraph 11-21).

Beacon antenna connection is through the S-Band Power Divider to three "C" and "S" Band Beacon antennas.

11-23. HF/UHF Recovery Beacon

Two recovery beacons are combined into one unit. One beacon operates on high frequency, while the other operates on ultra high frequency. Both are energized to provide radio signals for recovery direction finder equipment. (See Figure 11-12).

The HF recovery beacon operates on a frequency of 8.364 MC with a tone modulated output. It is powered by the 12 volt standby bus through the impact relay and is energized upon landing. The RF power output is fed through the rescue diplexer to the elevated HF recovery antenna.

The UHF recovery beacon operates on a frequency of 243 MC with pulse modulation. It is powered by the 6 volt isolated bus through the antenna fairing separation relay. This circuit is energized during re-entry when the antenna fairing is jettisoned. The RF power output is fed through the antenna multiplexer and the antenna switch to the UHF recovery antenna.

11-24. Auxiliary Rescue Beacon

The Aux. Rescue Beacon operates on a frequency of 243 MC with pulse modulation. It is powered by the 6 volt standby bus through the emergency hold relay #2 and the 10 minute delay impact relay. These circuits are energized 10 minutes

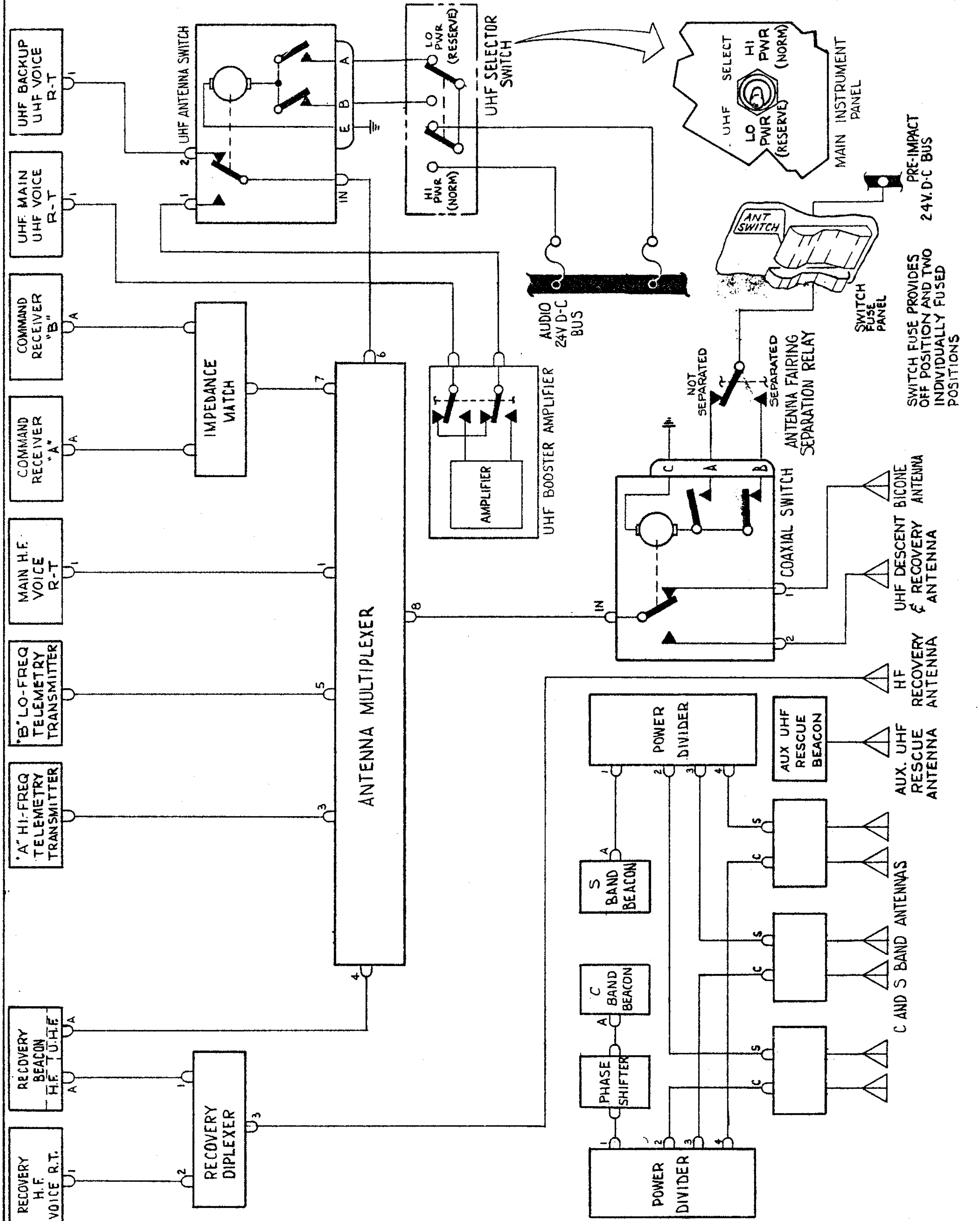


FIGURE 11-13 ANTENNA SYSTEM SCHEMATIC (CAPSULES 10,13,16,18 & 19)

PM45-1056

~~CONFIDENTIAL~~

after impact. The RF power is radiated from the Aux. Rescue Beacon Antenna. (See Figure 11-12).

11-25. Antennas

11-26. Main Bicone (HF and UHF)

A biconical antenna is used for pre-launch, launch, orbit and initial re-entry phases of the mission. This antenna is an integral part of the antenna fairing and is located over the open end of the recovery system compartment of the cylindrical capsule afterbody. The biconical antenna serves the main HF and UHF voice receiver-transmitters, the command receivers, and the telemetry transmitters. The active element of the biconical antenna forms the upper portion of the antenna fairing while the lower portion of the fairing and the capsule body forms the ground plane for the antenna. (See Figure 11-13).

11-27. UHF Recovery Antenna

A UHF antenna is used for the final phase of re-entry, landing and rescue. It is a compact antenna located on the open surface of the recovery systems compartment. The antenna is folded when the antenna fairing is installed. Sixteen seconds after the fairing is jettisoned the UHF recovery antenna is erected and serves the UHF voice receiver-transmitters, the UHF portion of the recovery beacon, the command receivers, and the telemetry transmitter. The main HF voice receiver-transmitter is connected and operating but radiation from this antenna is negligible. (See Figure 11-6).

11-28. Main Bicone and UHF Recovery Antenna Feed

The various radio systems are connected to the bicone antenna or the UHF recovery antenna in the following manner: (See Figure 11-13).

(1) The main HF voice receiver-transmitter antenna lead is connected to the antenna multiplexer.

(2) The UHF Selector Switch determines whether the hi-power or the lo-power

UHF receiver-transmitter is used. It also energizes the UHF coax switch to connect the operating UHF set to the antenna multiplexer.

(3) The two command receiver antenna leads are connected to an impedance matching network. This enables both receivers to share a single antenna lead from the impedance match to the antenna multiplexer.

(4) The Hi and Lo frequency telemetry transmitters each feed directly to the antenna multiplexer.

11-29. Antenna Multiplexer

The antenna multiplexer enables simultaneous or individual operation of the radio systems using one antenna. Effectively this is a radio frequency junction box. Final connection to the antenna is through the antenna switch to either the biconical antenna, or the UHF recovery antenna. The antenna switch is operated by the antenna fairing separation relay to cause the automatic shift from the main antenna to the UHF recovery antenna upon antenna fairing jettison. (See Figure 11-13).

11-30. Recovery Antenna

An antenna is provided to permit HF radio transmission and reception after landing. The antenna is a telescoping whip antenna which is automatically extended by gas pressure after impact. Once extended, the antenna is used for the HF rescue voice receiver-transmitter and the HF portion of the recovery beacon.

Antenna leads from the HF recovery voice receiver-transmitter and the HF recovery beacon are connected to the HF recovery diplexer. This diplexer allows simultaneous or individual operation over the single lead to the antenna. (See Figure 11-13).

11-31. C and S Band Antennas

Three C and S band antenna units are installed in the capsule structure for the C and S-band beacons. These units are equally spaced about the circumference of the conical section. Each antenna unit consists of one helix as a C-band antenna and one helix as an S-band antenna.

Antenna leads from the C-band and S-band beacons are routed through individual power dividers to the three associated helix antennas. (See Figure 11-13).

11-32. <u>SYSTEM UNITS</u>

11-33. AUDIO CENTER

The audio center provides transistorized audio amplifiers, a "voice operated relay" (VOX), an audio filter, tape recorder control circuitry and transmitter control circuitry. (See Figure 11-1). All components are contained in a light weight, foam encapsulated unit.

Two fixed gain headset amplifiers are used to bring audio signals up to headset level and feed the headsets separately. Two fixed gain amplifiers are provided to increase the dynamic microphone output to a level suitable to be used with the various transmitters.

A low pass filter, with a cutoff for frequencies above 300 cps, filters the audio supplied from the command receivers. Outputs from the filter is fed to a variable gain, command audio amplifier.

The "voice operated relay" is a transistorized amplifier with separate adjustable threshold level and release time controls. The amplifier operates a relay to provide a grounding circuit for transmitter control. This unit parallels the external microphone switch.

The audio center furnishes a circuit to apply the transmitter control ground potential to the various transmitters. Each circuit is protected from the rest by a crystal diode.

A relay is installed in the audio center for supplying power and audio signals to the tape recorder. In the de-energized condition, the relay closes a circuit to the tape recorder input, thus audio received by the capsule is recorded whenever instrumentation programs tape recorder operation.

When the microphone switch or VOX is operated, the tape recorder relay is energized. One set of closed relay contacts now completes the recorder power circuit independent of instrumentation programming, while a second set of contacts routes signal from the microphone amplifiers to the recorder input.

The circuits in the audio center operate directly from the capsule 24 volt d-c inputs with no further regulation or voltage increase.

11-34. CONTROL PANEL

The audio control panel provides controls and circuits for the audio signals of the various capsule receivers. (See Figure 11-7).

The two HF and two UHF circuits are routed through individual T-pads to volume controls. The two HF circuits share a single volume control, the same is true of the two UHF circuits, while separate volume control is provided for the command audio circuit. Fixed inputs are used for the alarm tone and ground interphone circuits.

The panel also contains a switch override for the impact keying feature used with the UHF transmitters, and keying button on the panel to interrupt the Hi-Frequency telemetry B+ supply during emergency keying. (Refer to Figure 11-10).

11-35. MAIN HF VOICE RECEIVER-TRANSMITTER

The main HF voice set is an AM receiver-transmitter designed as a small, light weight unit operating near 15 MC. (See Figure 11-8).

The receiver section of the unit is a transistorized circuit using a crystal filter, crystal diode detector and class B audio amplifier. The final audio amplifier is used for sidetone during transmissions.

The transmitter section of the unit utilizes vacuum tube stages for the crystal controlled oscillator, driver and power amplifier. The power amplifier may be modulated up to 90% by a transistorized speech amplifier and modulator. These audio stages are also used for sidetone. Transmitter output is 5 watts. Capsule power, 24 volts d-c, is supplied to the unit, with voltage regulator provided by a Zener diode, transistor circuit. Power is routed through an external switch and contacts of the capsule separation relay which controls transmitter filament power, relay operation and a transistorized power converter. High voltage from this converter is used for the transmitter power amplifier. Antenna switching is accomplished by a solid state circuit which blocks the receiver during transmission. D-c voltage is also removed from the receiver RF stages.

11-36. RECOVERY HF VOICE RECEIVER-TRANSMITTER

The HF Recovery voice set is similar to the main set. (See Figure 11-8). The main difference lies in the transmitter section. This section consists of a crystal controlled oscillator and power amplifier delivering 1 watt output.

11-37. HIGH POWER (MAIN) AND LOW POWER (BACKUP) UHF VOICE RECEIVER-TRANSMITTER

The main and backup sets are identical. (See Figure 11-9). They consist of an AM receiver-transmitter designed as a small, lightweight unit operating near 297 MC. Transmitter output is .5 watt. The main receiver-transmitter is boosted in output by a final booster amplifier.

The receiver section of the unit is a transistorized superheterodyne circuit using a crystal controlled local oscillator, crystal filter and crystal diode detector. The audio section of the receiver also serves as the speech amplifier, modulator and provides sidetone for the transmitter. The transmitter section of the unit utilizes a crystal controlled oscillator, tripler and power amplifier. The RF section uses vacuum tubes while the modulation circuits are transistorized.

Capsule power, 24 volts d-c, is supplied to the set. This voltage is applied to the receiver, audio circuits and back through an external transmit switch to an internal power converter. This transistorized converter supplies B+ voltage to the transmitter RF sections. Transmitter filament voltage is also applied by the external transmit switch or the bicone separation relay after bicone separation.

Switching from receiver to transmitter operation is accomplished when ground potential is applied to a switching relay and a blocking circuit. The relay provides antenna and power converter switching. The blocking circuit removes receiver voltage.

11-38. UHF BOOSTER AMPLIFIER

A booster amplifier is used prior to landing to increase the .5 watt output of the Main UHF transmitter to 2.0 watts. The higher power is also available after landing.

Signal input to the booster is routed through a double pole, double throw relay. When the relay is de-energized, the signal is routed through the contacts to the output jack. Energizing the relay feeds the signal through the amplifier and takes the amplifier output to the output jack.

11-39. COMMAND RECEIVER-DECODERS

The command receiver-decoder is a transistorized unit consisting of an FM receiver designed to operate in the frequency range of 406 to 450 MC, and a decoder unit to operate control circuits. (See Figure 11-10).

The receiver section of the unit is a dual conversion superheterodyne circuit. The first local oscillator is crystal controlled and uses two stages of frequency multiplication. Two stages of amplification are used for the first IF, 78 MC signal. The second local oscillator is also crystal controlled, mixing with the first IF and giving a resultant second IF of 10.75 MC. Output from the IF strip is through a limiter to the discriminator. Audio amplifiers boost the discriminator output for the command voice channel and the decoder driver. The driver in turn supplies the ten decoder channels in the set.

The individual decoder channels each provide filters for their specific command frequency and amplifiers to operate a double pole, double throw relay for each channel. The ten relays thus make available normally open and normally closed contacts for external control circuit operation.

Capsule power, 18 volts d-c, is used to power the set. A Zener diode circuit, within the unit, is used for voltage regulation.

11-40. AUXILIARY DECODERS

An auxiliary decoder operates with each of the two receiver-decoder units, allowing an additional ten channel capability.

The decoder channels in the auxiliary decoder are identical to the decoder channels of the receiver-decoder, with the exception of the command frequencies at which they operate.

The auxiliary decoder operates from capsule 18 volt d-c power. No further voltage regulation or increase is required.

11-41. TELEMETRY POWER SUPPLIES (See Figure 11-11)

The telemetry power supplies generate voltage used in the telemetry transmitters. The unit is transistorized and uses crystal diodes. Capsule power, 24 volts d-c, is applied to a transistor switching circuit operating into the primary of a power transformer.

A full wave, crystal diode rectifier is used on one secondary, with voltage regulation, to provide 200 volts d-c.

11-42. TELEMETRY TRANSMITTERS

The two telemetry transmitters are essentially identical (See Figure 11-11). They must be ground adjusted for an output of 3.3 watts. One set is operated at approximately 228 MC while the other is tuned to approximately 260 MC.

The transmitter is an FM unit using modulation inputs from instrumentation circuits. Modulation signals are applied to the oscillator which through four stages of doubling feeds a power amplifier stage. All stages, with the exception of the final doubler and the power amplifier, are transistorized. Filament voltage, 6.3 volts and B+ voltage, 200 volts d-c, are obtained from the separate power supply. Capsule power, 24 volts d-c, is applied to the transmitter which provides voltage regulation.

11-43. C-BAND BEACON

The C-Band transponder is a pressurized superheterodyne receiver and pulse modulated, 400 watt peak output transmitter, operating in the frequency range of 5400 to 5900 MC (See Figure 11-12). With the exception of the magnetron, the unit is transistorized. The receiver consists of a pre-selector, local oscillator, 40 MC IF amplifier strip, pulse detector, pulse amplifier and decoder. Resonant cavities are used for the pre-selector and local oscillator.

The transmitter section accepts decoder outputs and pulse modulates the transmitter output.

The unit contains a power supply for converting capsule 24 volt d-c input to filtered 24 volt d-c and regulated, 115 and 150 volts d-c outputs. Antenna switching is through an internal diplexer.

11-44. S-BAND BEACON

The S-Band transponder is a pressurized superheterodyne receiver and pulse modulated, 1000 watt peak output transmitter operating in the frequency range of 2700 to 2900 MC. (See Figure 11-12). Like the C-Band beacon, the unit is transistorized except for the output tube.

Receiver and transmitter circuits are the same as those used in the C-Band beacon with the exception of the pre-selector, local oscillator and transmitter which are designed for S-Band frequencies.

11-45. HF/UHF RECOVERY BEACON (See Figure 11-12)

The recovery beacon combines an HF, tone modulated, 8.364 MC transmitter and a UHF, pulse modulated, 243 MC transmitter into one small, foam encapsulated unit. The UHF section of the beacon is a one tube circuit with a pulse coding network. The HF section of the beacon is a transistorized crystal oscillator and two stage power amplifier with tone modulation supplied from a power converter. The beacon utilizes 6 and 12 volts d-c from the capsule power system. The UHF section is energized by applying the 6 volt d-c to a transistorized power converter. A full wave, crystal diode circuit is used to rectify the power converter output which is applied to the UHF stage. Applying 12 volts d-c energizes the HF section of the beacon. No power converter is required for the 12 volt input.

Modulation for the HF section is provided by routing the 12 volt supply to the power amplifier stages through a secondary winding of the power converter.

11-46. AUXILIARY UHF RESCUE BEACON

The Aux. UHF Rescue Beacon, consists of a pulse modulated transmitter and power supply which is enclosed in a foam-encapsulated case. (See Figure 11-12). The unit is connected to the 6 volt standby bus and has an output of 91 watts.

11-47. ANTENNA MULTIPLEXER

The antenna multiplexer allows reception and transmission of the many capsule frequencies over one line to the bicone or UHF recovery antenna. The unit consists of a number of filters arranged so that all capsule frequencies between 15 and 450 MC can be multiplexed on the single feed line. Each input channel is provided 60 db of isolation.

11-48. RECOVERY DIPLEXER

The recovery diplexer unit is used for the HF recovery voice receiver-transmitter and HF section of the recovery beacon. One low pass and one high pass filter is used to diplex 8.364 and 15 MC on one feed line to the HF recovery antenna.

11-49. COAXIAL SWITCHES (ANTENNA SWITCH)

RF switching is accomplished with motor driven SPDT switches. Application of capsule 24 volts d-c through external circuits drives the switch to the appropriate RF position and opens the power circuit for that position.

11-50. BICONE ANTENNA

The capsule is electrically divided in two sections. (See Figure 11-6). The antenna fairing structure at the junction of these sections resembles a discone antenna. This junction is center fed by a coaxial cable from the communications sets. At frequencies between 225 and 450 MC the antenna fairing acts like discone antenna. A lower frequency of 15 MC causes the unit to resemble an "off center fed" dipole. Between the upper and lower limits, at 108 MC, the unit behaves as a composite dipole-discone antenna.

Thus the bicone antenna serves all capsule frequencies, with the exception of C and S-bands, allowing reception and transmission within limits of the capsule system.

11-51. BICONE ISOLATOR

An isolator is provided to shield electrical wires that pass through the bicone antenna fairing structure. The isolator is formed into a tube which is curved to allow mounting beneath the periphery of the antenna fairing.

11-52. UHF DESCENT AND RECOVERY ANTENNA

The UHF descent and recovery antenna takes over the UHF functions of the bicone antenna when the antenna fairing is jettisoned. (See Figure 11-6). The UHF descent and recovery antenna is a fan shaped, vertically polarized monopole located on the top of the recovery compartment.

11-53. HF RECOVERY ANTENNA

Upon landing, impact circuits initiate a sequence for the HF recovery antenna. (See Figure 11-6). The elevated antenna acts as a vertically polarized monopole for HF frequencies.

11-54. C AND S-BAND ANTENNAS

Three antenna units serve the C and S band beacons. (See Figure 11-6). Each unit consists of a C and a S band radiator. Each radiator is a cavity mounted helix antenna.

11-55. TEST CONFIGURATION CAPSULES

The data contained in Paragraphs 11-1 through 11-54 applies to the specification compliance capsule. Deviations from this data as applicable to test configuration capsules are covered in the following paragraphs. Differences mainly involve such things as UHF Transmitter power output, pre-recorded tape method of voice modulating transmitters, sequencing differences in transmitter operation, umbilical control of C and S band beacons. Certain items common to the manned capsule will not be utilized in some other capsule, such as the telemetering key, push to talk switch, umbilical interphone, headset amplifier output and beacon switch modes of operation. (For operation of systems see Communications Table 11-1). If no reference is made to a particular item, it is the same as the specification compliance capsule.

11-56. TEST CONFIGURATION CAPSULE NO. 8

Communication systems on Capsule No. 8 are the same as the Specification Compliance Capsule except that Capsule No. 8 is intended for an unmanned mission therefore data pertaining to Astronaut control is either programmed within the capsule or remotely controlled by ground command through the Command Receivers and De-coders. Differences are explained in paragraphs 11-57 thru 11-67. (See Figures 11-15 thru 11-25).

11-57. Voice Communications

Voice communication for Capsule No. 8 is similar to the Specification Compliance Capsule, except Capsule No. 8 is un-manned and is equipped with a playback tape recorder containing a pre-recorded tape to simulate the Astronaut's voice which will modulate the HF and UHF transmitters in the capsule. (See Figures 11-15, 11-19 and 11-22). This playback tape recorder is provided with a dual track recording. The output is staggered as shown on Figure 11-14. Starting of the tape recorder is controlled at the beginning of the mission by the CAMERA AND TAPE RECORDER Switch in the blockhouse or the additional tape record relay (see Instrumentation Section XIII). The playback tape recorder operation begins prior to launch and continues throughout the mission until tape depletion. Duration of tape recorder running time is approximately 45 minutes. Single ended output from the playback tape recorder is fed to the two separate microphone amplifiers in the audio center which energizes the voice operated relay circuit in the Audio Center. The voice operated relay in turn completes a ground circuit to the tape recorder relay thus causing the modulation signal to be routed to the main tape recorder as well as modulating the HF and UHF transmitters. A push to talk switch is not utilized.

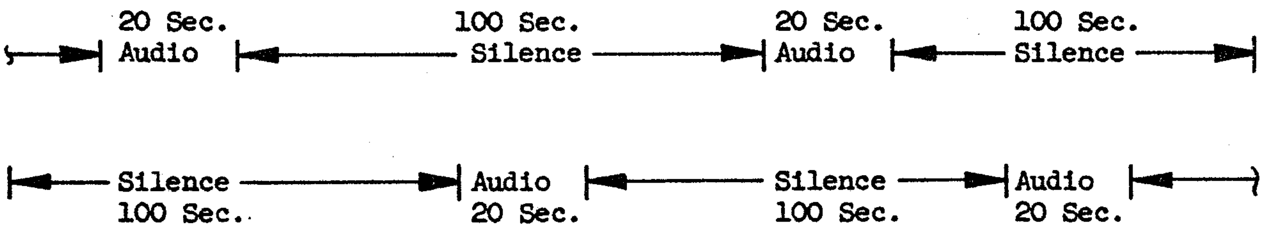


FIGURE 11-14 PRE-RECORDED TAPE SEQUENCE

11-58. HF Voice Communications

The HF Communication Tape Recorder will transmit the playback recorder signal alternately 20 seconds "on" and 100 seconds "off" until bicone separation or until the pre-recorded tape is exhausted, whichever occurs first. Audio output from the HF Receiver is directed into the main tape recorder only, since the headsets and amplifiers are not utilized. After impact HF Communications is conducted through the HF Recovery Tape Recorder. (See Figures 11-15 and 11-20).

11-59. UHF Voice Communications

Operation of the UHF Main Tape Recorder (T/R) is similar to the Specification Capsule (refer to Paragraph 11-14) except the UHF Booster Amplifier is not installed. The transmitter is modulated by the playback recorder and the receiver output is fed into the main tape recorder similar to the HF Comm. T/R except that an extra channel in the main tape recorder is utilized to record the UHF receiver audio. The UHF Voice Communications set is not utilized unless the UHF Selector Switch should be placed in the "UHF" position prior to launch. UHF

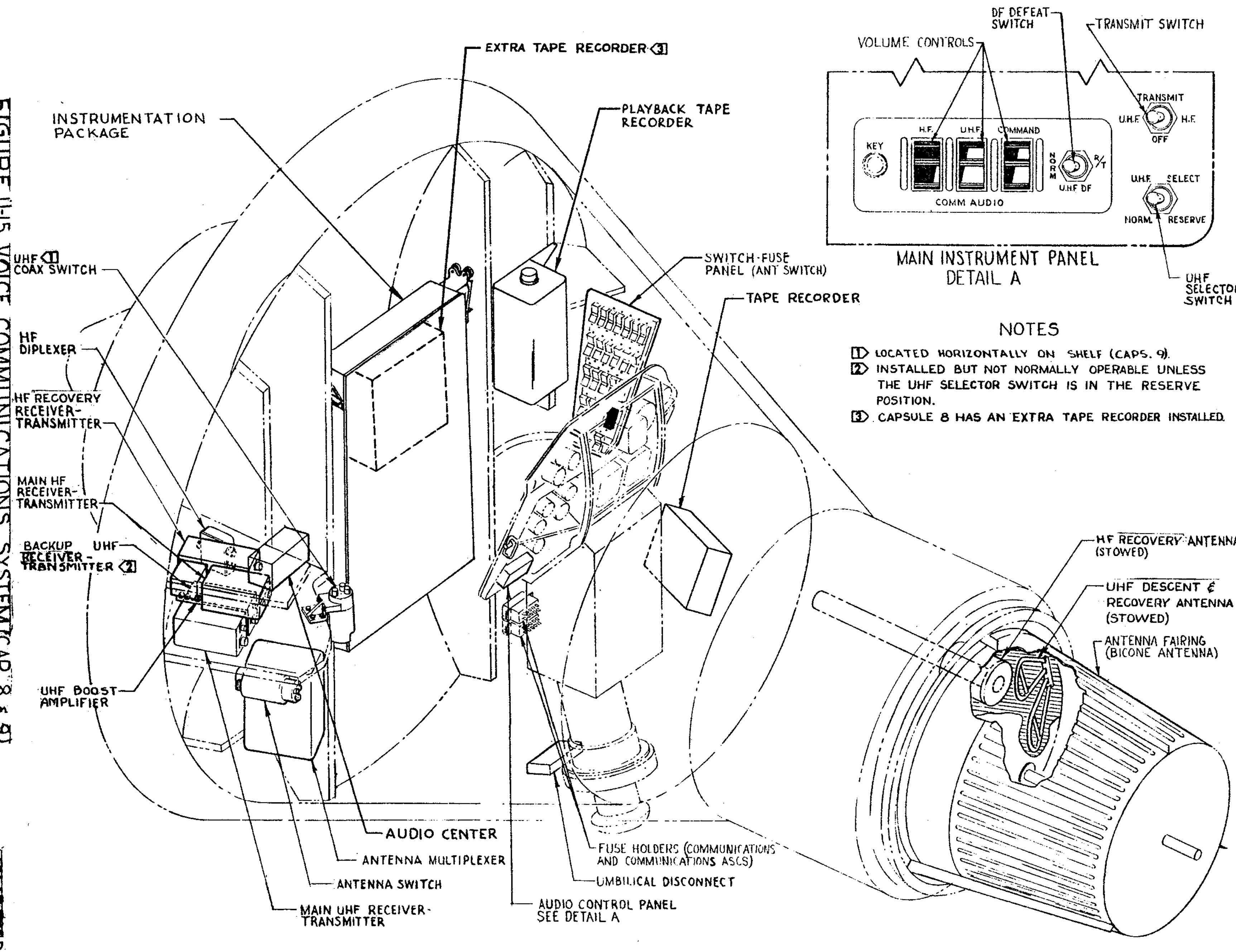


FIGURE 11-15 VOICE COMMUNICATIONS SYSTEM (CAP. 8 & 9)

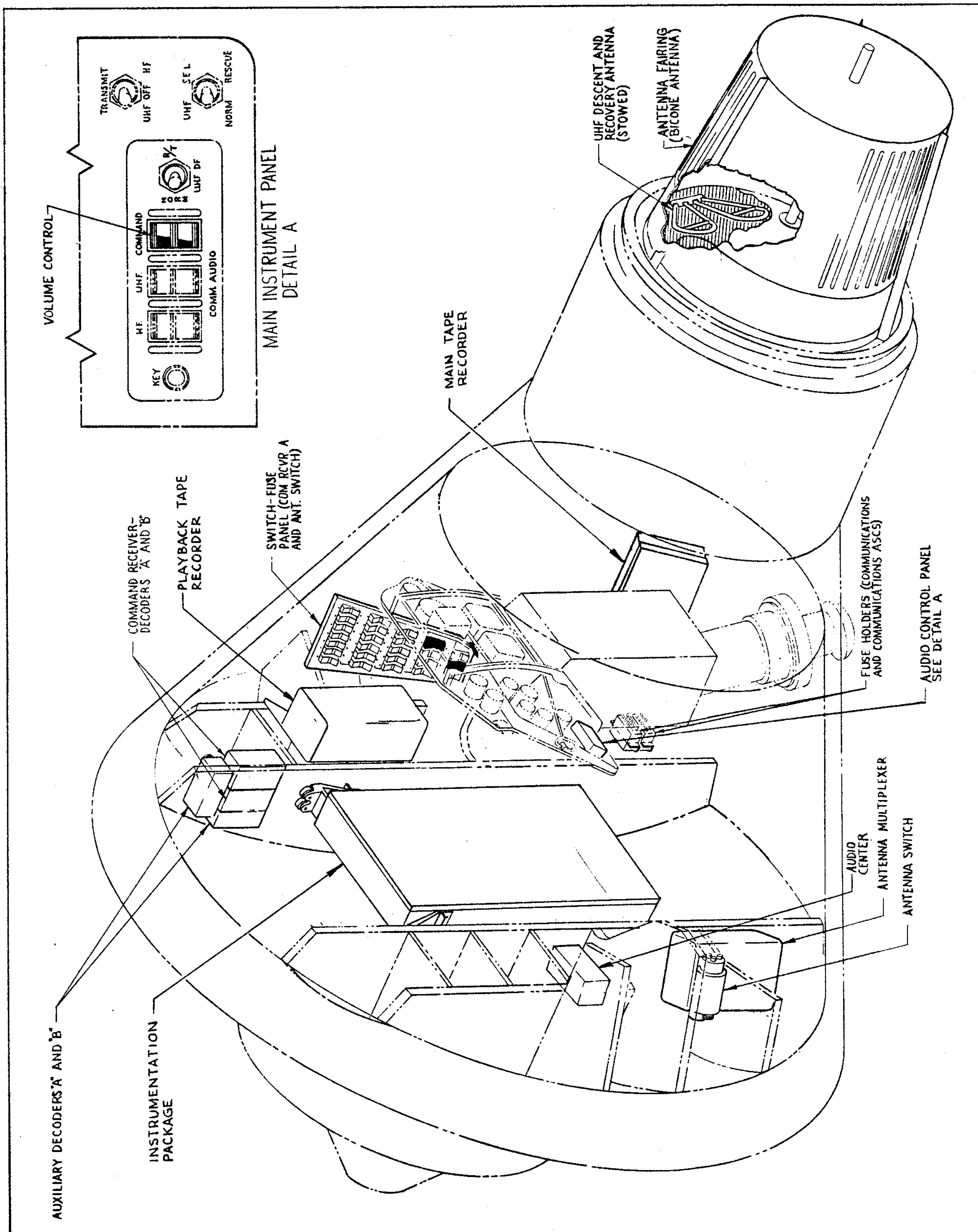


FIGURE 11-16 COMMAND RECEIVERS SYSTEM INSTALLATION (CAPSULES 8 & 9)

PM45-186B

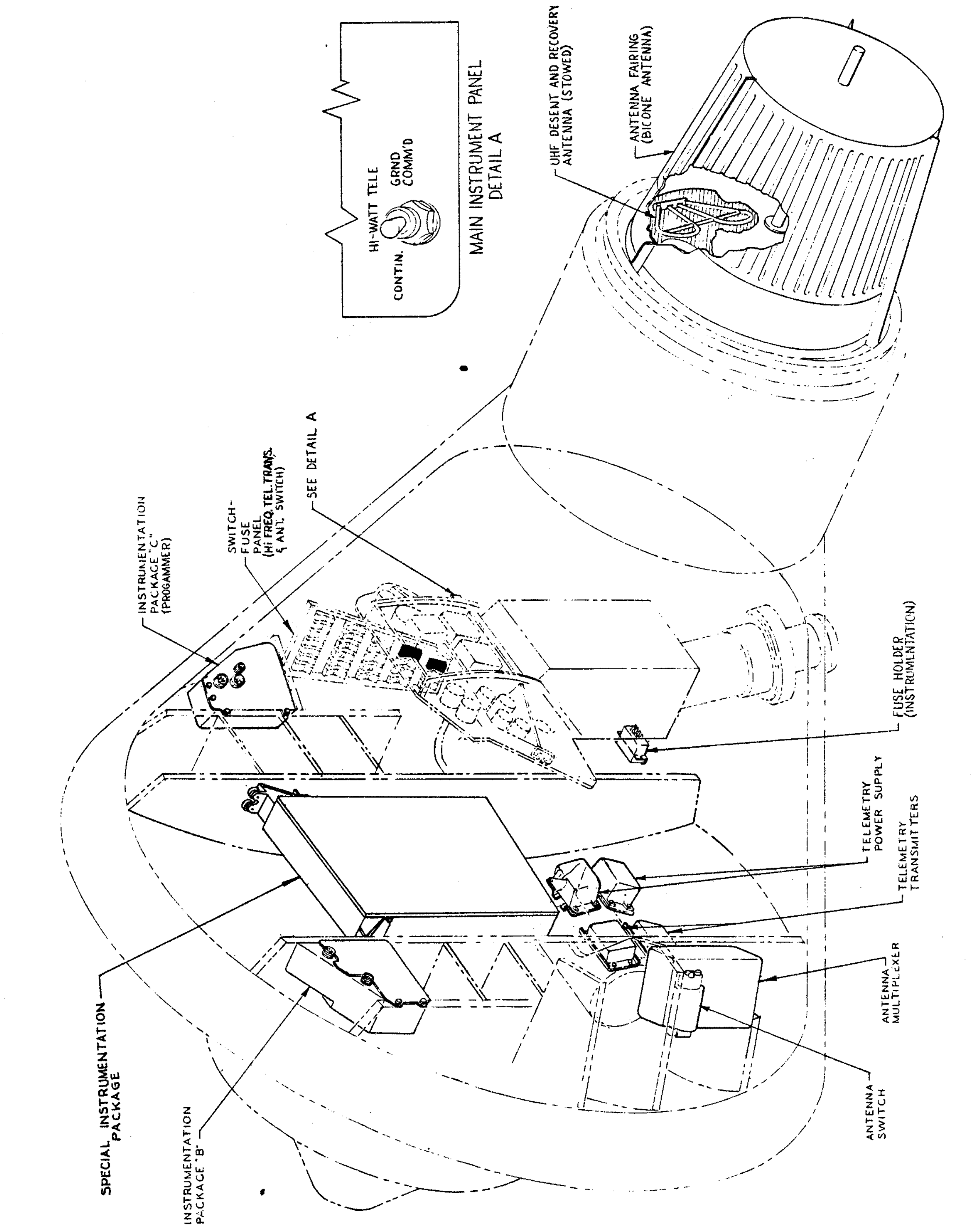


FIGURE 11-17 TELEMETRY SYSTEM (CAPSULES 8 & 9)

PM45-189E

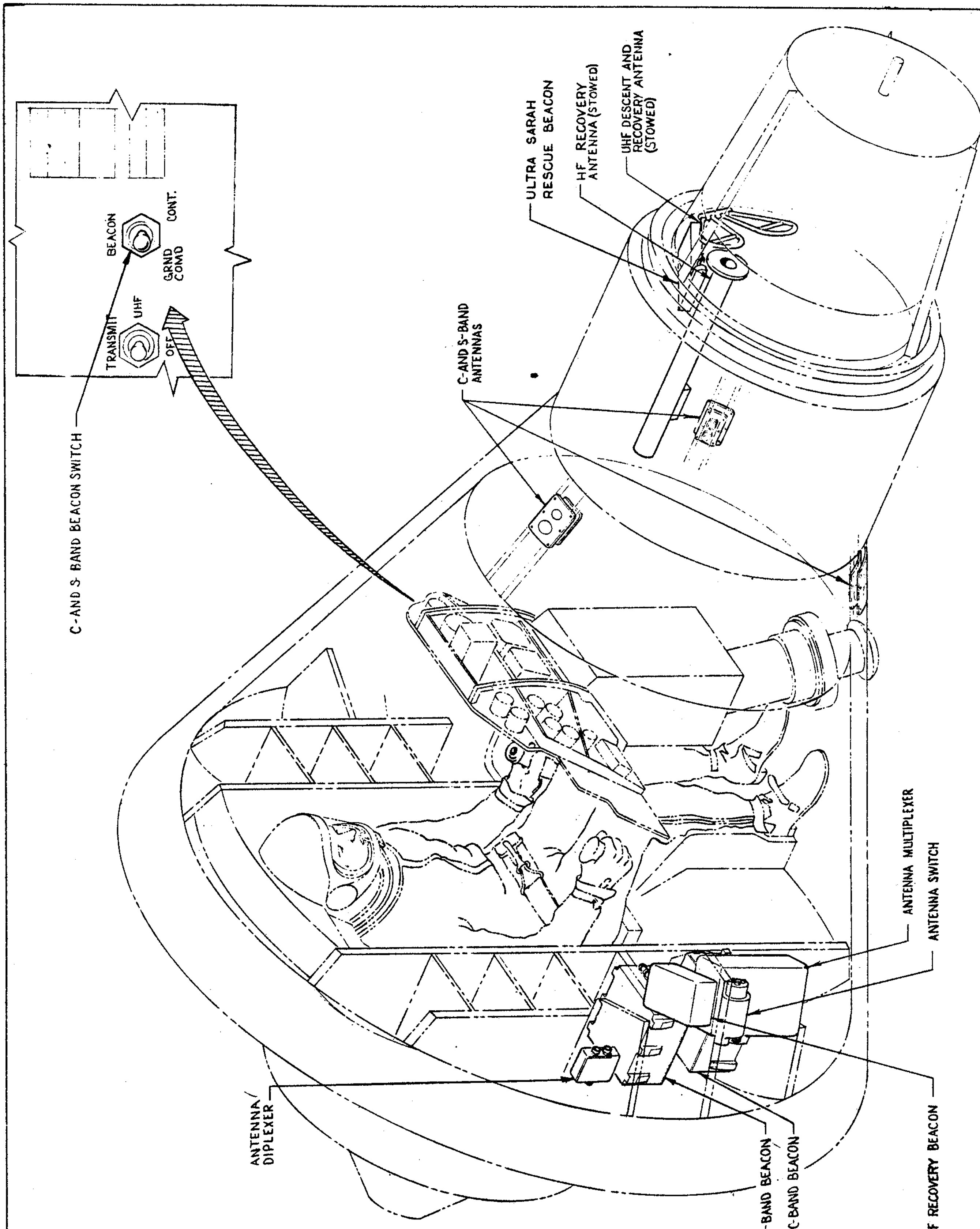


FIGURE 11-18 BEACONS SYSTEM (CAPSULES 8 & 9)

transmission and reception is available throughout the mission, after impact the receiver will continue to feed its output to the main tape recorder, and the transmitter will emit voice signals until the pre-recorded tape is depleted after which a CW signal will be transmitted. The CW signal also serves as a direction finder signal. (See Figure 11-15 and 11-21).

11-60. HF Recovery Tape Recorder

HF Recovery Tape Recorder (T/R) operation is similar to the Specification Compliance Capsule (Refer to Paragraph 11-12), except that after impact the transmitter will emit the pre-recorded tape voice signal until the tape is depleted, after which a CW signal will be emitted. The HF Recovery T/R is connected to an automatically raised whip type antenna. (See Figures 11-15 and 11-20).

11-61. Command Receivers

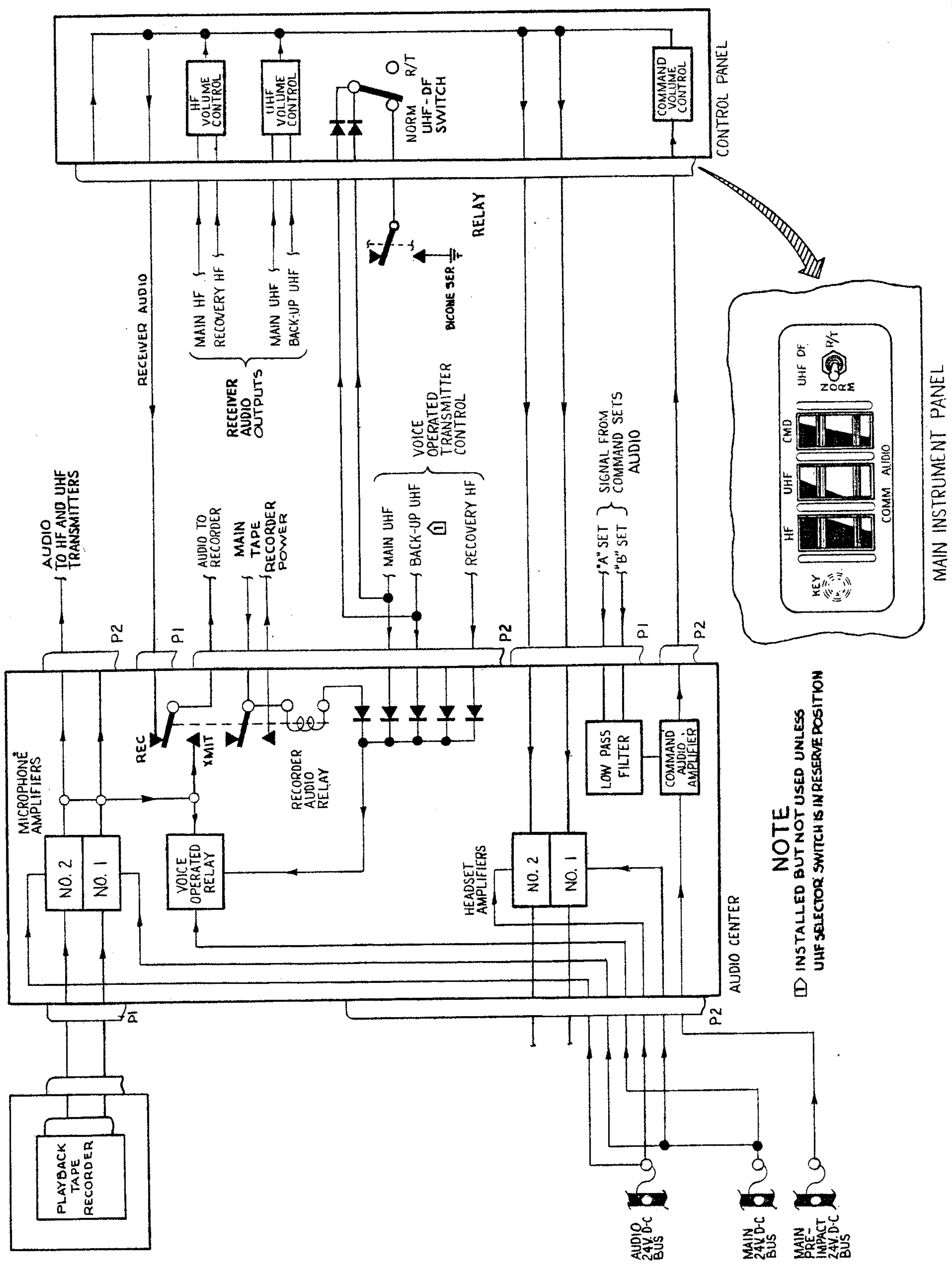
The Ground Command Receiver operation is the same as the Specification Compliance Capsule (Refer to Paragraph 11-16), except the audio is routed into the main tape recorder instead of into the Astronaut's headset which is not used. The C and S Band Beacon operation is controlled through the command receivers. (See Figures 11-16 and 11-22).

11-62. Telemetry

The two telemetry transmitters perform their functions in the same manner as in the Specification Compliance Capsules (Refer to Paragraphs 11-18 and 11-19) except that operation is continuous from launch to impact. (See Figures 11-17 and 11-23).

11-63. C and S Band Beacons

Operation of the C and S Band Beacons is the same as the Specification Compliance Capsule (refer to Paragraphs 11-21 and 11-22), except that both beacons operate continuously throughout the mission. The beacon switch must



NOTE
1 INSTALLED BUT NOT USED UNLESS UHF SELECTOR SWITCH IS IN RESERVE POSITION

FIGURE 11-19 AUDIO CONTROL SYSTEM (CAPSULES 8 & 9)

PM45-190D

CONFIDENTIAL

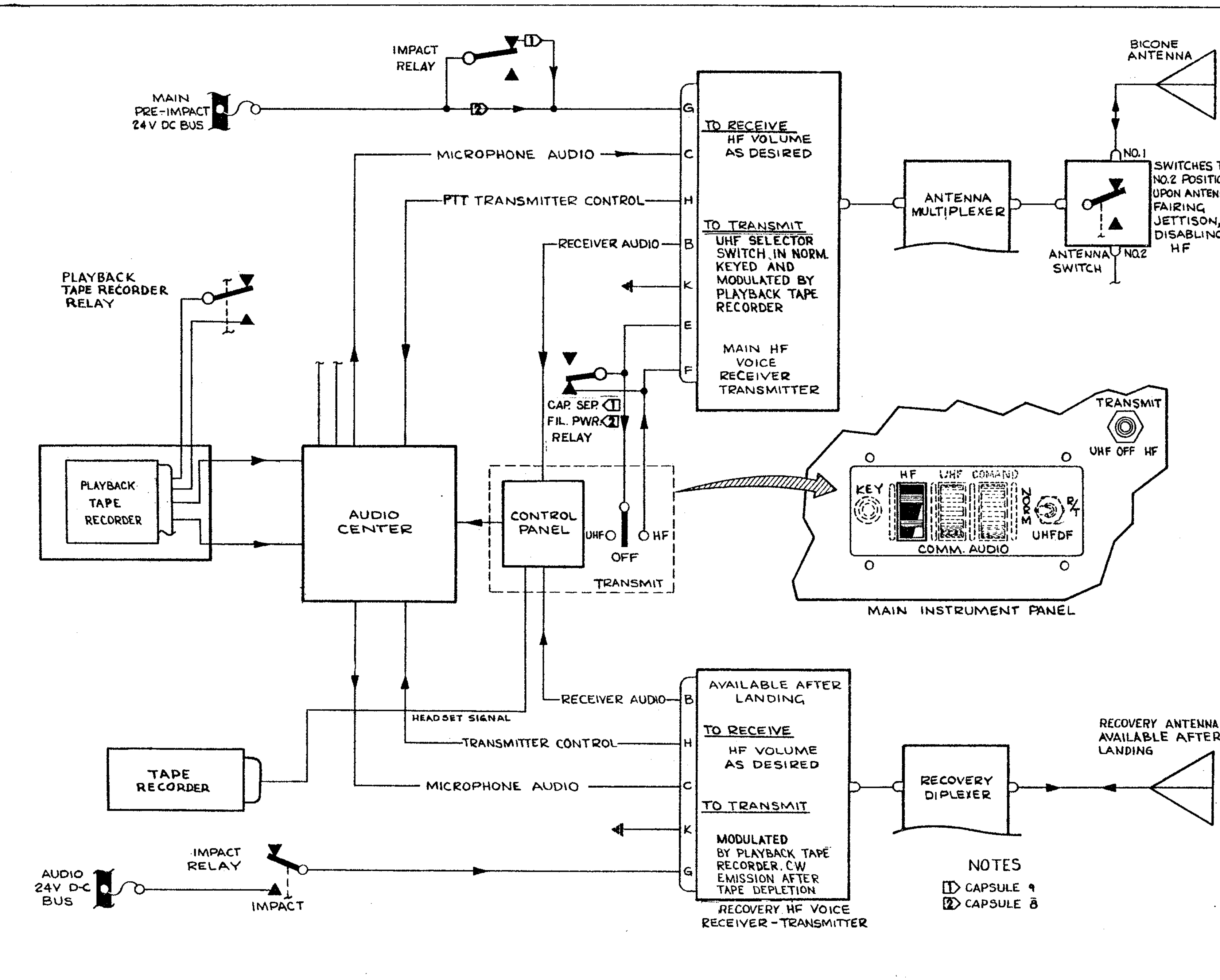


FIGURE 11-20 HF VOICE COMMUNICATIONS DATA FLOW (CAPS. 8 & 9)

PI45-187C

CONFIDENTIAL

~~CONFIDENTIAL~~

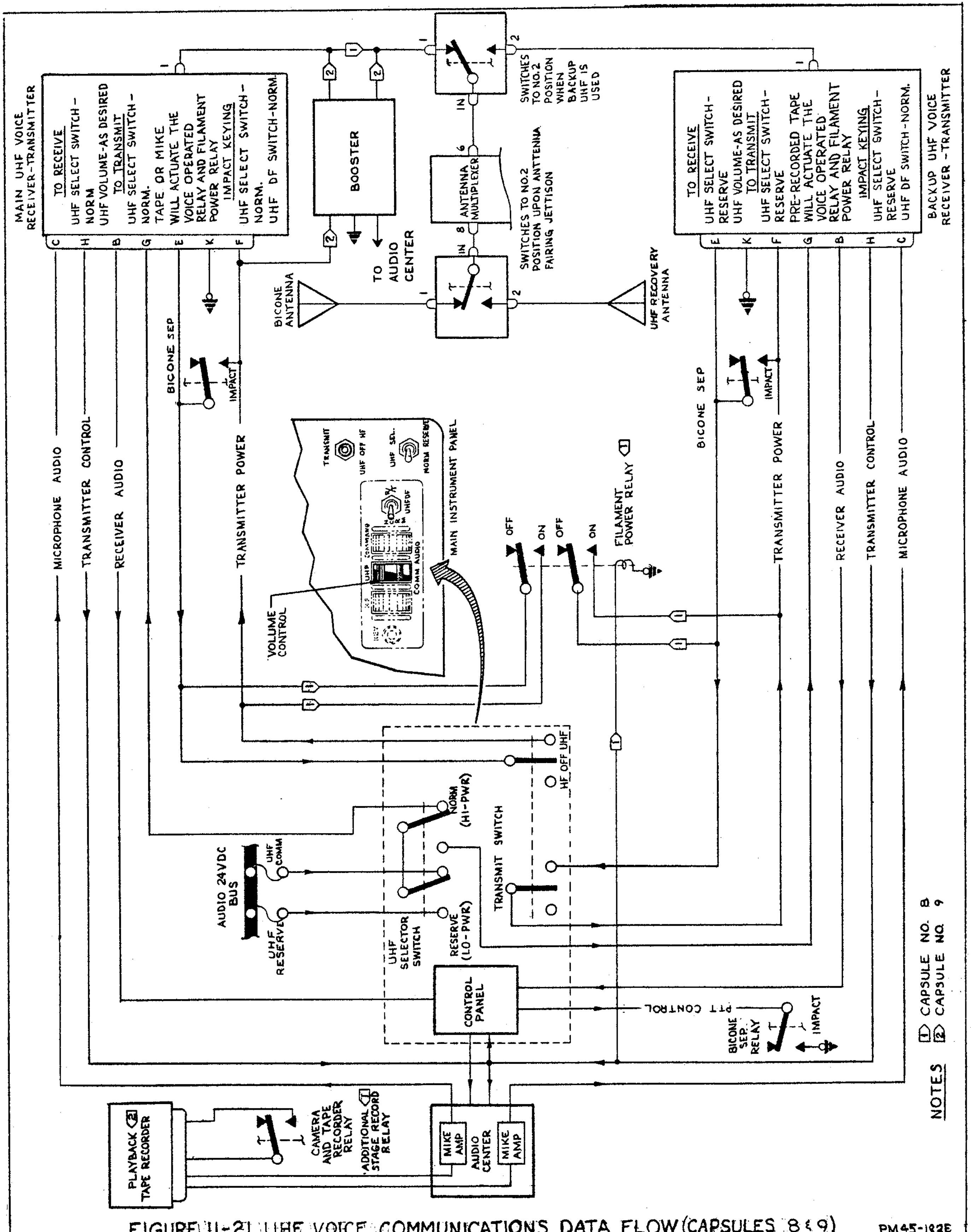


FIGURE 11-21 UHF VOICE COMMUNICATIONS DATA FLOW (CAPSULES 8 & 9)

PM45-182E

~~CONFIDENTIAL~~

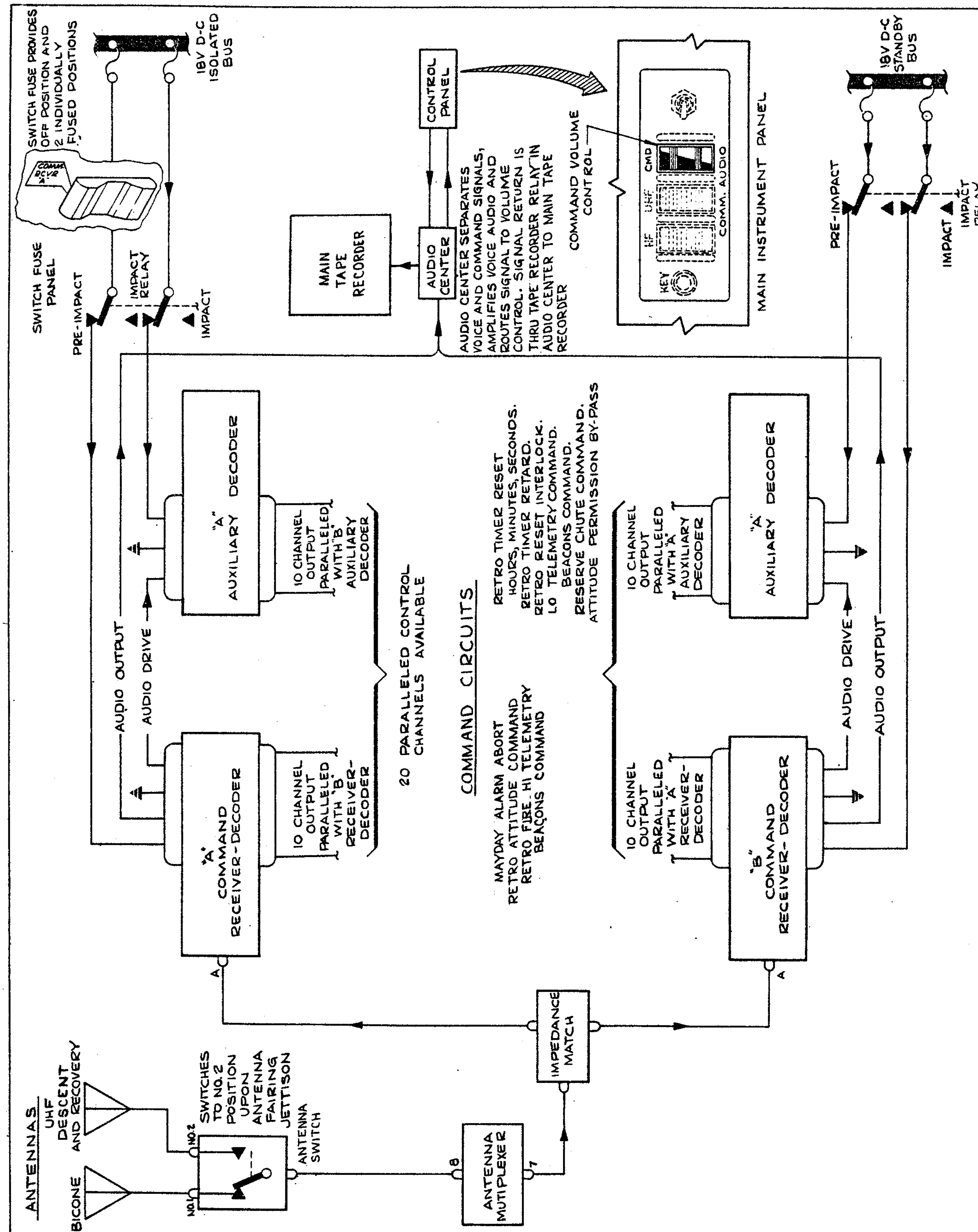
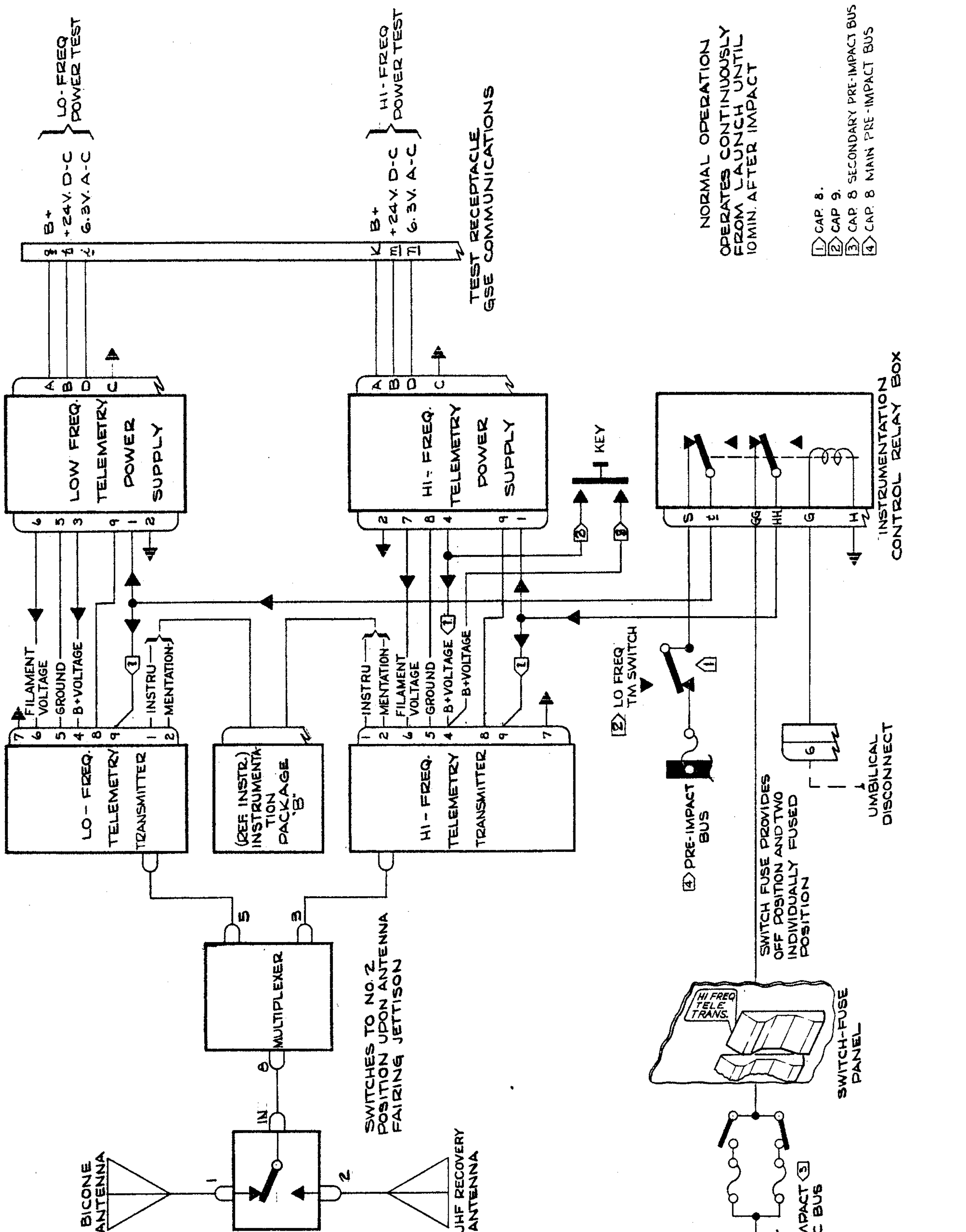


FIGURE 11-22 COMMAND RECEIVERS DATA FLOW (CAP 8 & 9)

McDONNELL *Aircraft Corporation*
ST. LOUIS, MISSOURI

CONFIDENTIAL



(CAPSULES 8, 9)
FIGURE 11-23 TELEMETRY SYSTEM DATA FLOW

PM45-191E

CONFIDENTIAL

CONFIDENTIAL

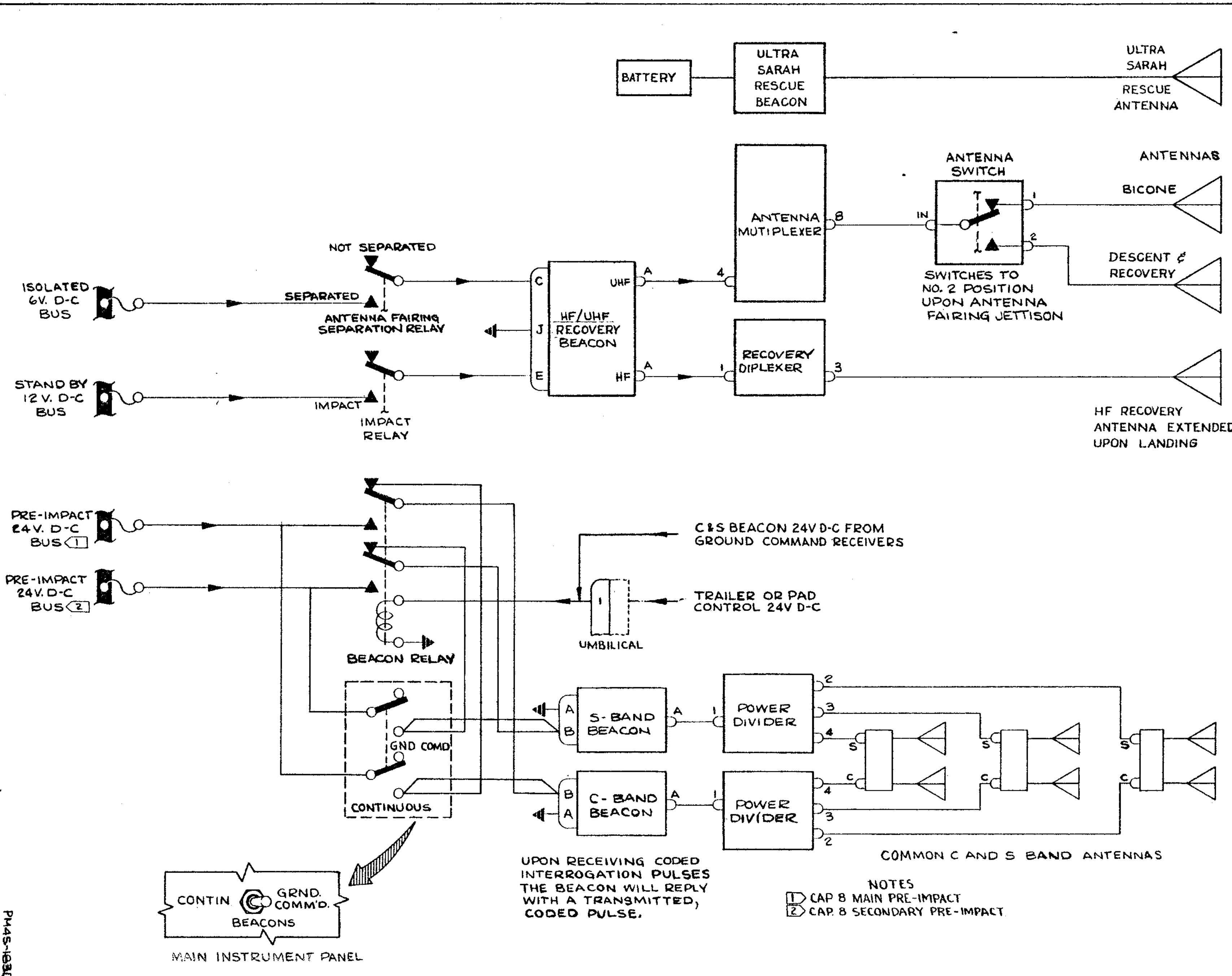


FIGURE 11-24 BEACON SYSTEM DATA FLOW (CAPSULES 8 & 9)

CONFIDENTIAL

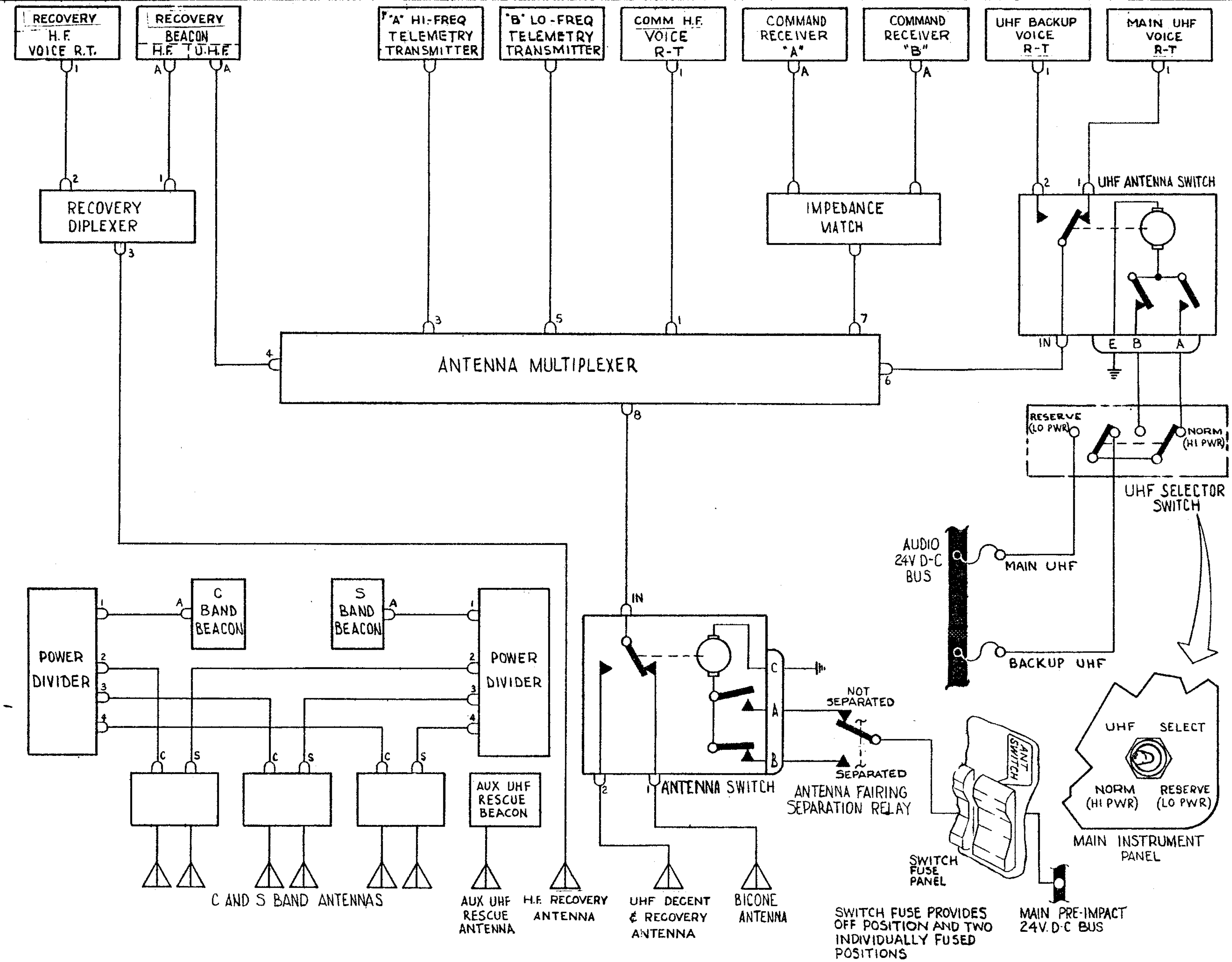


FIGURE 11-25 ANTENNA SYSTEM SCHEMATIC (CAPSULES 8 & 9)

PM45-184D

be placed in the "Continuous" position prior to launch. The S-Band Beacon is double pulsed as on the Specification Compliance Capsule but the C-Band Beacon is single pulsed which requires different ground coding for interrogation. (See Figure 11-24).

11-64. Auxiliary UHF Rescue Beacon and Antenna

Capsule No. 8 does not have the Aux. UHF Rescue Beacon installed, however it is equipped with an ultra Sarah Rescue Beacon which is a self-contained unit, energized by bicone antenna separation and operation is automatic. (See Figure 11-24.)

11-65. Antennas

The antennas used on Capsule No. 8 are the same as the Specification Compliance Capsule (Refer to Paragraphs 11-25 thru 11-31).

11-66. Main Instrument Panel

Capsule No. 8 does not use a tone generator.

11-67. Special Instrumentation

Capsule No. 8 is equipped with special instrumentation and incorporates an extra capsule tape recorder. This tape recorder is located in the special instrumentation pallet and consists of a power supply and seven channels for recording. The extra tape recorder is controlled through the communications control panel (Refer to Section XIII Instrumentation.).

11-68. TEST CONFIGURATION CAPSULE NO. 9

Capsule No. 9 is the same as the Specification Compliance Capsule except for differences as noted in Paragraphs 11-69 through 11-71. (See Figures 11-15 through 11-25).

11-69. Voice Communications

Voice communications for Capsule No. 9 is similar to the Specification Compliance Capsule except a playback tape recorder is installed to simulate the

Astronaut's voice, as in Capsule No. 8. A Special Instrumentation Relay is installed to provide playback tape recorder control. (Refer to Paragraph 11-57).

11-70. C and S Beacons

Operation of the C and S Band Beacons is the same as the Specification Compliance Capsule (Refer to Paragraphs 11-21 and 11-22), except that both beacons are on continuous. The beacons switch must be placed in the "Continuous" position prior to launch.

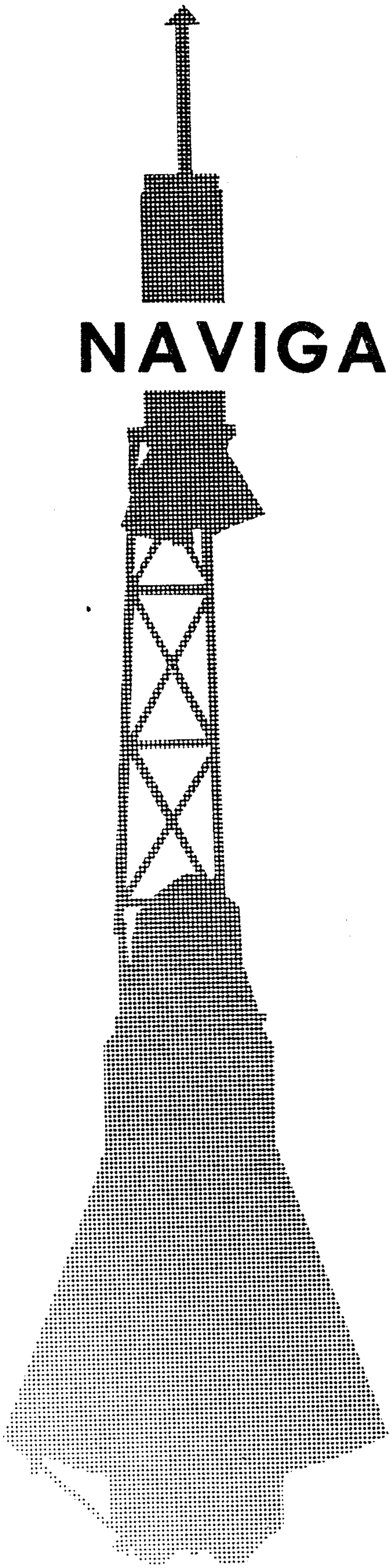
11-71. Auxiliary UHF Rescue Beacon and Antenna

Capsule No. 9 does not have the Aux. UHF Rescue Beacon installed, however, it is equipped with an Ultra Sarah Rescue Beacon, which is a self contained unit, energized by bicone antenna separation and operation is automatic. (See Figure 11-25).

11-72. TEST CONFIGURATION CAPSULES NO. 10, 13 AND 16

Communications on Capsules No. 10, 13 and 16 are the same as the Specification Compliance Capsule (Refer to Paragraphs 11-1 thru 11-54).

SECTION XII



NAVIGATIONAL AIDS

TABLE OF CONTENTS

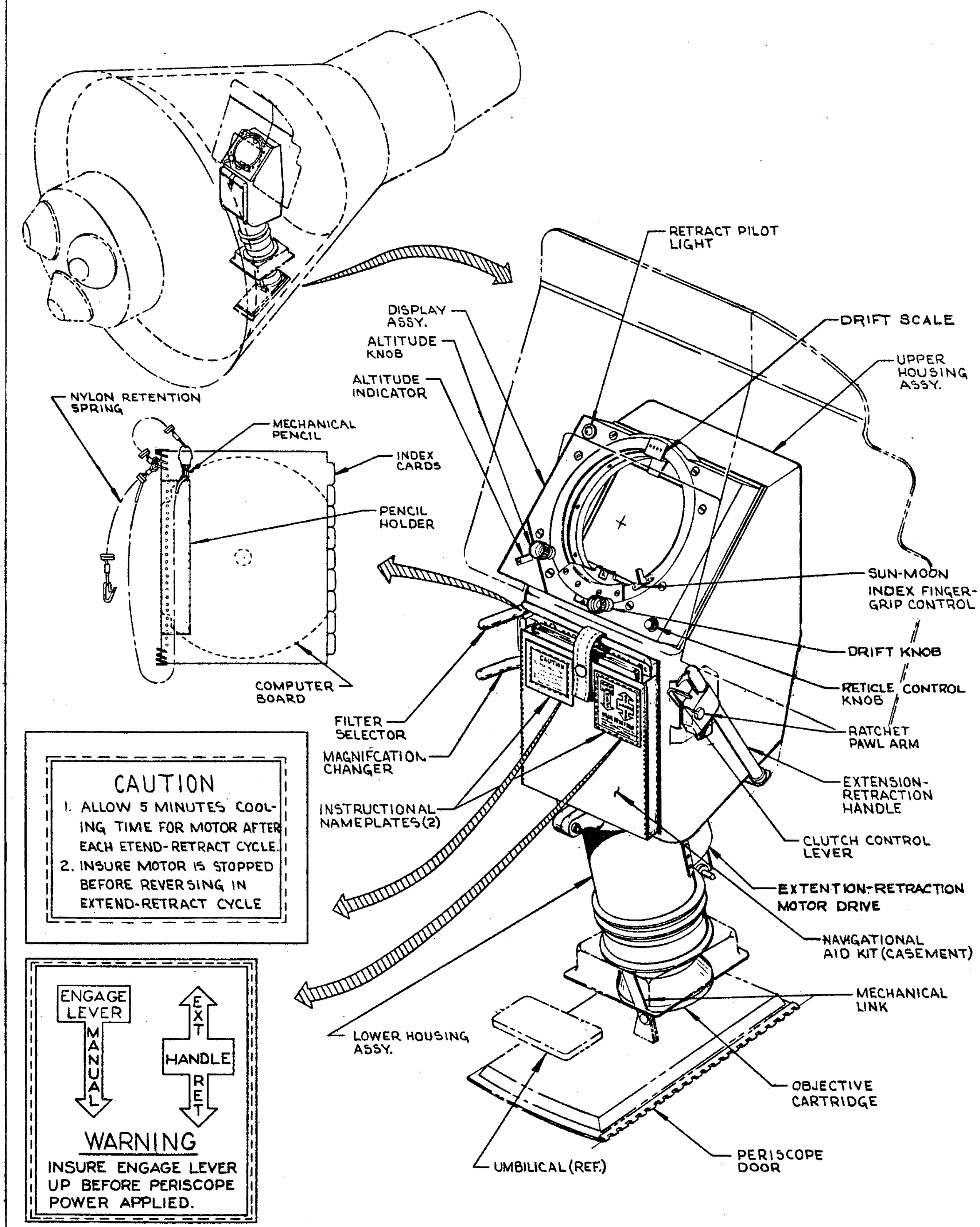


FIGURE 12-1 PERISCOPE ASSEMBLY (SHEET 1 OF 2)

PM45-110C-1

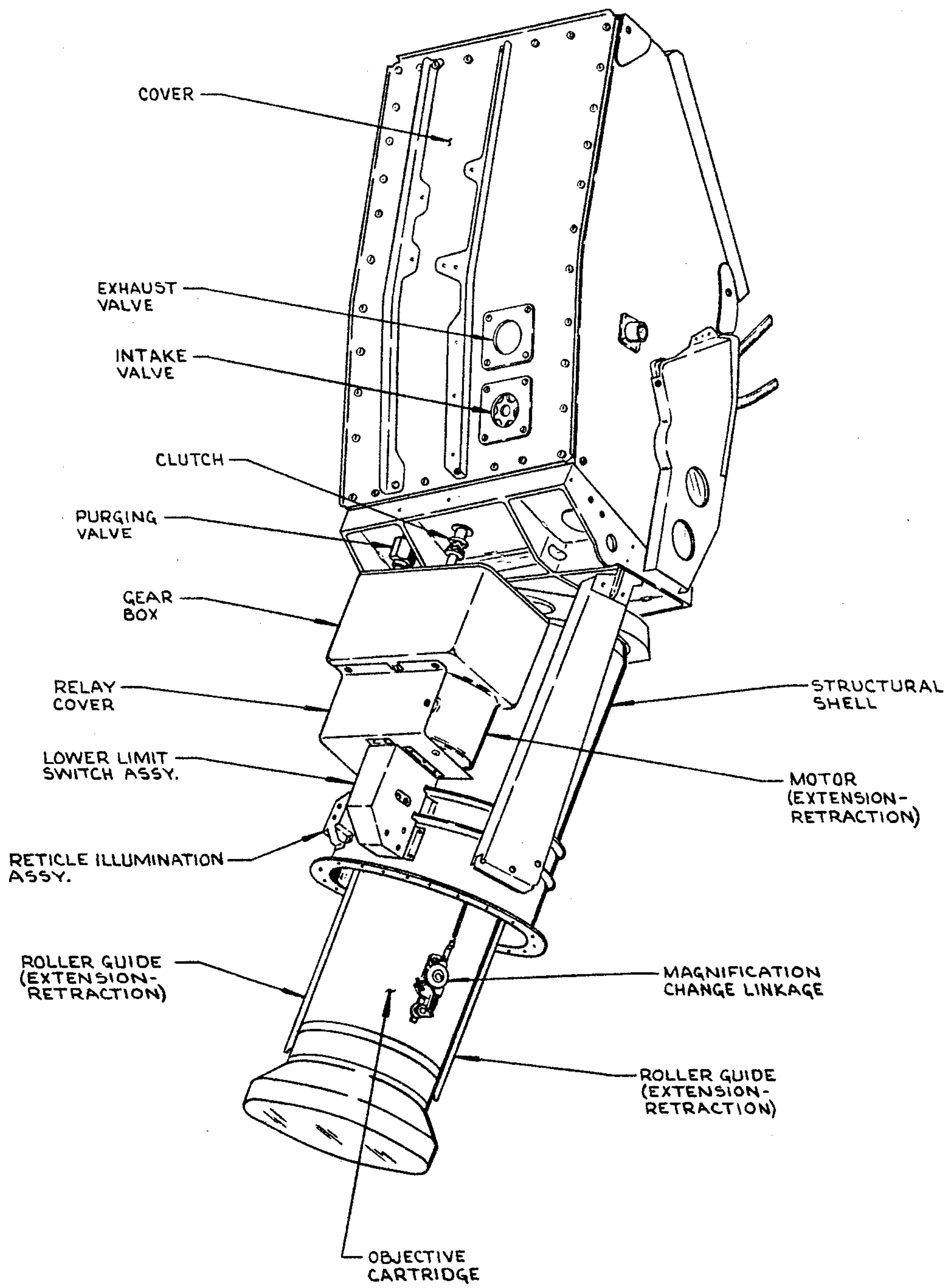


FIGURE 12-1 PERISCOPE ASSEMBLY (SHEET 2 OF 2)

PM45-110-2

XII. NAVIGATIONAL AIDS AND INSTRUMENTS

12-1. GENERAL

Normally the Astronaut will not find it necessary to compute any of the factors relative to his flight or landing. In the event the need should arise, however, the Astronaut is provided with all the equipment required to compute altitude, course, velocity and landing data, and to attain and maintain the proper attitude for each phase of the flight.

12-2. PERISCOPE DESCRIPTION

The periscope is a compact navigational instrument designed to withstand loads up to 100 G's. The periscope consists of three major assemblies: The display assembly, the upper housing assembly, and the lower housing assembly. (See Figure 12-1.) The periscope is mounted in the capsule so that the objective cartridge may be extended and retracted through a periscope door opening in the bottom of the capsule. The opening and closing of the periscope door is synchronized with the extension and retraction of the objective cartridge by means of a mechanical link. Periscope programming, during a normal mission, begins with the periscope extended while the capsule and booster are still on the pad. Upon capsule umbilical disconnect, the periscope retracts and remains retracted until capsule separation. At this time the periscope extends and remains extended during orbit. Thirty seconds after retro-package separation, the periscope is again retracted. At approximately 10,000 feet altitude, the periscope is extended for the last time and remains extended throughout impact. Following umbilical disconnect and just prior to launch, if the "HOLD" sequence is initiated, the periscope will automatically extend. Located on the left hand console is the RETRACT SCOPE telelight and a switch which has AUTO and MAN

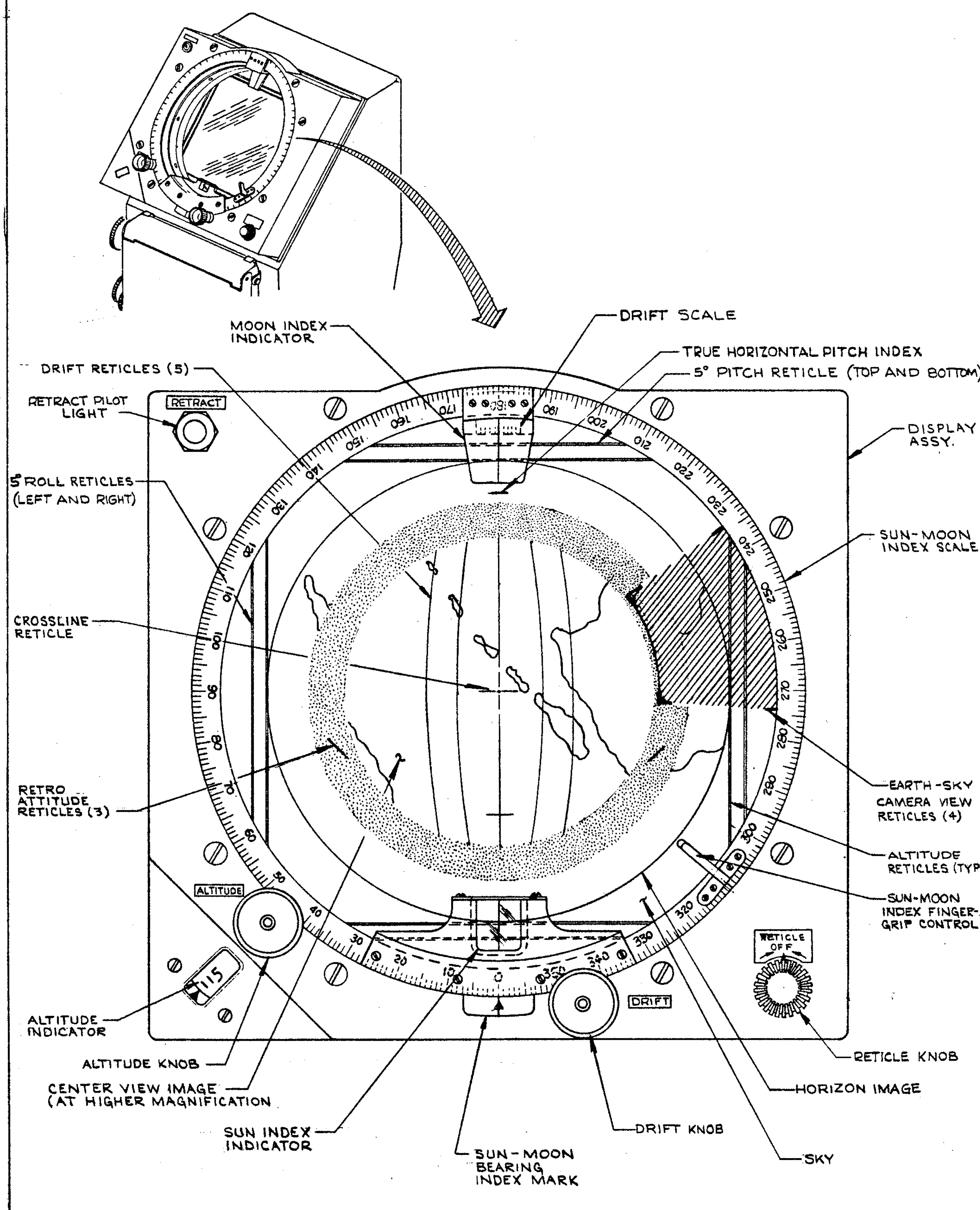
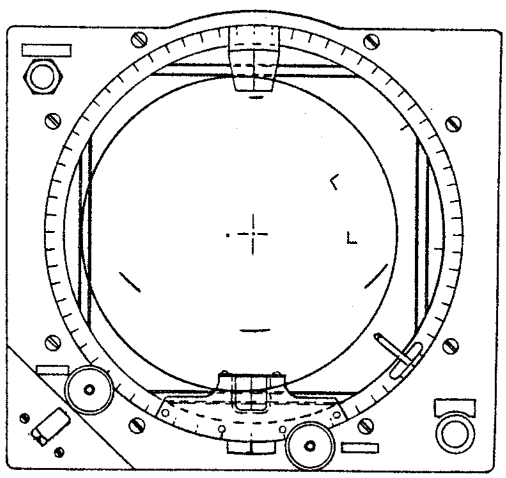
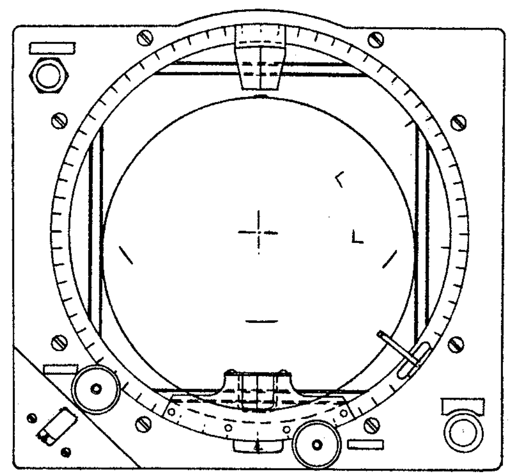


FIGURE 12-2 PERISCOPE DISPLAY (SHEET 1 OF 2 SHEETS)

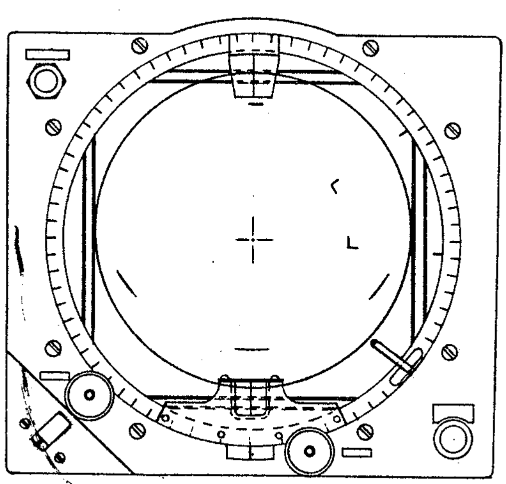
PM45-112A-1



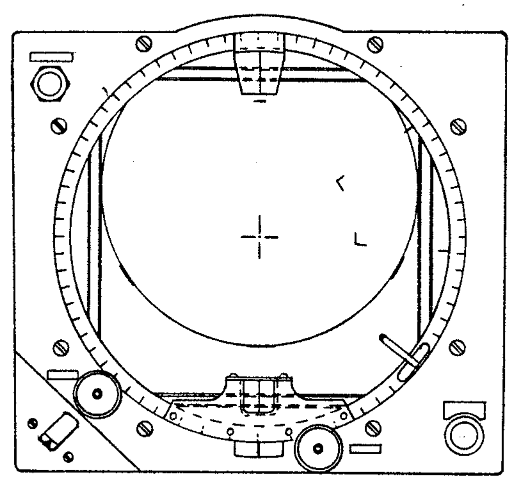
5° LEFT ROLL
EXAMPLE NO. 1.



CAPSULE LEVEL
EXAMPLE NO. 2.



CAPSULE SMALL END
PITCHED 5° BELOW ORBIT ATTITUDE
EXAMPLE NO. 3.



CAPSULE IN RETROGRADE
ATTITUDE
EXAMPLE NO. 4.

FIGURE 12-2 PERISCOPE DISPLAY (SHEET 2 OF 2)

PM45-112-2

positions. If the periscope does not retract 40 seconds after retro-package separation, the RETRACT SCOPE telelight will go on. The switch is then placed in the MAN position and the periscope is retracted manually. The following navigational information can be obtained concerning the capsule's position relative to the earth: Drift, altitude, pitch, roll, true vertical, retro angle, field of view of the earth-sky camera and relative bearings of the sun and moon.

12-3. DISPLAY ASSEMBLY

The display assembly (See Figure 12-1 and 12-2) includes the following: Scales, indicators, altitude reticles, attitude reticles and the controls for their manipulation, earth image, horizon image and the retract pilot light. It is mounted at the top of the upper housing assembly. The display assembly provides the Astronaut with a visual indication of the capsule's altitude and attitude relative to the earth. It also provides him with the necessary indicators and scales for obtaining bearings relative to the sun and moon. When the earth is centered in the display, the portion of the image bordering the altitude reticles will depict the earth's horizon. The center of the view (crossline reticle) represents a vertical line to the center of the spherical earth (see Figure 12-3). Image erection is such that the horizon and straight down views are true.

12-4. <u>True Vertical and Optical Vertical</u>

In the true vertical attitude (see Figure 12-3), as compared to the optically vertical attitude, the longitudinal axis of the capsule is perpendicular to a line through the center of the spherical earth. The capsule is optically vertical with respect to the earth when the capsule is pitched nose down at $14\frac{1}{2}$ degree angle.

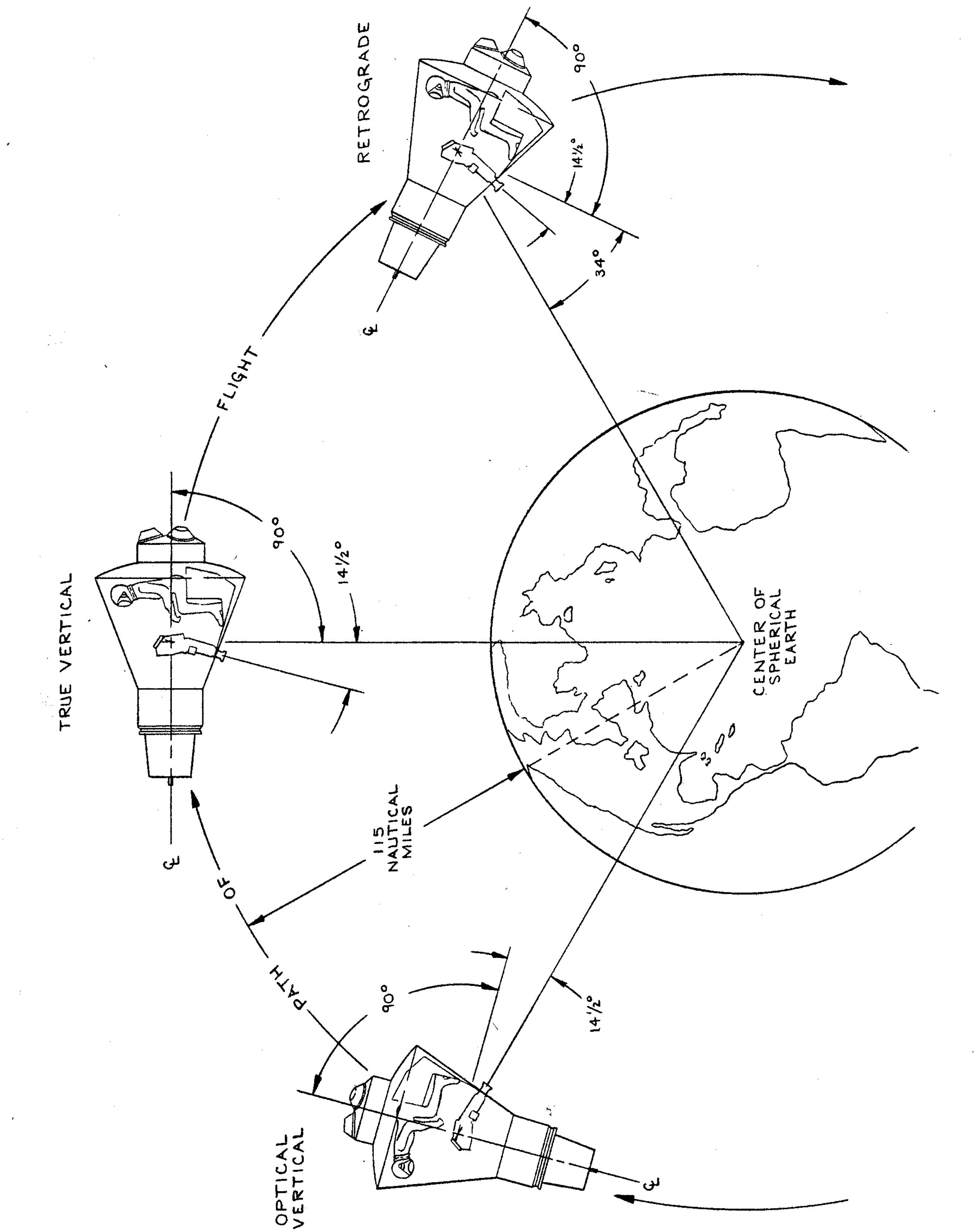


FIGURE 12-3 VEHICLE ATTITUDES

PM45-263

12-5. Altitude

When the capsule is in the optically vertical attitude, the altitude of the capsule may be determined by means of the altitude mechanism. This mechanism includes four pairs of altitude reticles, which form a square within the circular display area, the altitude knob and the altitude indicator (see Figure 12-2). Turning the altitude knob moves the reticles to change the size of the square and also rotates the scale of the altitude indicator. To determine altitude, the knob is turned to change the size of the square until the earth's image is inscribed within the inner square formed by the reticles. The altitude is then read from the altitude indicator. The point on the earth's surface vertically below the capsule is indicated by the crossline reticle which appears at the center of the display area. The crossline reticle is illuminated by a lamp, the brightness of which is controlled by the reticle knob. The altitude indication range extends from 50 to 250 nautical miles. The altitude mechanism is calibrated to indicate altitude within ± 5 nautical miles within the range of 100 to 140 nautical miles, within ± 10 nautical miles at altitudes below 100 nautical miles and within ± 50 nautical miles at altitudes above 140 nautical miles.

12-6. Pitch and Roll

The pitch and roll degree of the capsule with respect to its optical vertical attitude may be approximated by use of the altitude mechanism (see Paragraph 12-5). The distance between the parallel curves which form each side of the altitude reticle square is equivalent to a 5-degree angle at an altitude of 115 nautical miles. If the vehicle is off pitch, it will be impossible to adjust the reticle square so that both the fore and the aft reticle curves (reticle curves relative to the 180° and 0° positions on the drift scale) are tangent to the earth image. If the vehicle is off in roll, it will similarly be impossible to make the left and right reticle curves tangent to the earth image. To determine the approximate pitch angle, the reticle square is adjusted so that the horizon image lies across either the fore or aft (depending upon the direction of pitch) inner reticle curve by approximately the same amount that the opposite horizon edge lies inside the opposite inner reticle curve (see Figure 12-2, Sheets 1 and 2). The degree of pitch is estimated by comparing the distance that the one side of the horizon image extends across the inner curve with the distance between the inner and outer curve. The approximate roll angle is determined in the same manner as pitch angle.

12-7. Drift

Vehicle drift is determined by reference to five parallel drift reticles etched on the face of the drift plate covering the circular display area (see Figure 12-2, Sheet 1). The drift plate is rotated by means of the drift knob. A clear plastic drift scale is mounted under the drift plate. The drift scale covers plus and minus 5 degrees of drift in increments of one degree. To determine drift, the periscope is set for high power magnification. The Astronaut then rotates the drift knob until the ground track of the capsule in the central high power view appears to parallel the drift lines. The drift of the capsule is then indicated by the position of the center drift line with respect to the drift scale.

12-8. Retrograde Angle

The retrograde reticles provide an indication of whether or not the capsule is in the proper retrograde attitude prior to re-entry. To achieve proper retrograde angle starting from the optically verticle attitude at an altitude of 115 nautical miles and with zero drift angle, the nose of the capsule must be pitched down until the horizon image at the bottom of the display is tangent to the three retrograde reticles which form an arc across the lower half of the display area (see Figure 12-2, Sheet 2).

12-9. Sun-Moon Index

A ring shaped sun-moon index scale, used to indicate relative bearings of sighted objects, is mounted so as to frame the circular display area (see Figure 12-2, Sheet 1). The index ring is manually rotated by means of a finger-grip control. The index scale is calibrated from zero to 360 degrees. A sun index indicator, which enables sighting on the sun to obtain bearings, is mounted at the zero degree position of the sun-moon index scale. A moon index indicator, which enables sighting on the moon for bearings, is mounted at the 180 degree position of the sun-moon index scale. Bearings are read off the sun-moon index scale at the sun-moon bearing index mark located on the display assembly directly in front of the Astronaut.

12-10. Earth-Sky Camera View

Four camera reticles located at the right center of the display area give the approximate outline of the field-of-view of the earth-sky camera which is included in the capsule equipment (see Figure 12-2, Sheet 1).

12-11. Orbit Velocity

The crossline reticle is used to aid in the computing of orbital velocity (see Figure 12-2, Sheet 1). A stopwatch is started as the first checkpoint passes under the crossline reticle. When the second checkpoint passes under the crossline reticle, the watch is stopped. With this elapsed time, the orbit velocity is computed by employing the satellite hand computer.

12-12. UPPER HOUSING ASSEMBLY

The upper housing assembly will incorporate the following functional components: Two periscope mirrors, a filter installation, a magnification change control mechanism, a manual extension-retraction control, a housing exhaust valve, a desiccator assembly which includes the housing intake valve and the housing purging valve.

12-13. Periscope Mirrors

The mirrors are so situated in the upper housing assembly as to present the earth's image at a convenient angle to the observer (see Figure 12-4).

12-14. Filters

The upper housing assembly contains a clear, a red, a yellow and a medium neutral density filter. The filters are mounted in a rack which can be rotated to position the desired filter in the optical path. The filter rack is manually driven through a system of pulleys and cables by means of the filter selector which is located on the left side of the upper housing assembly (see Figure 12-1, Sheet 1 of 2). Detents accurately position the filters with respect to the optical path.

12-15. Magnification Change Control

The periscope optic system is capable of high and low magnification. The change in magnification is brought about by manipulation of the magnification changer (see Figure 12-1, Sheet 1 of 2).

12-16. Manual Extension-Retraction Control

The manual extension-retraction mechanism enables the objective cartridge to be extended and retracted manually (see Figure 12-1, Sheet 1 of 2). The mechanism consists of a manually driven gear system which couples to the gear box and motor drive assembly of the lower housing assembly through a manually operated clutch. The gear system is driven by the ratchet handle on the right side of the upper housing assembly. The ratchet handle is pulled up to place it in operating position and pushed down to place it in the stowed position. For manual manipulation, the manual engage lever will be in the down position. The ratchet pawl arm will determine the direction of motion (see instructions affixed to navigational aid kit).

12-17. Intake and Exhaust Valve

The intake and exhaust valve (see Figure 12-1, Sheet 2 of 2) allows the upper housing to "breathe" without the passage of dirt to the inside of the upper housing. The intake valve is mounted in an intake valve body to which the intake end of a desiccant tube is attached. When the ambient cabin pressure exceeds that inside the upper housing, the intake valve admits air to the upper housing through a desiccant (silica gel). Moisture and dirt is thus removed from the entering air to minimize condensation and dust deposits on optical components. A purging valve (see Figure 1, Sheet 2 of 2) provides an inlet and an attachment point when purging the upper housing assembly with dry nitrogen gas.

12-18. LOWER HOUSING ASSEMBLY

The lower housing assembly consists of a structural shell housing the objective cartridge. The following items are mounted on the structural shell: Extension-retraction motor, gear box, lower limit switch assembly and a reticle illumination assembly (see Figure 12-1, Sheet 2 of 2).

12-19. Objective Cartridge

The objective cartridge houses the objective lens, power change lens and the collective lens (see Figure 12-4). It is mounted inside the structural shell. A connecting link between the objective cartridge and the periscope door allows the door to move in unison with the telescopic motion of the objective cartridge (see Figure 12-1).

12-20. Objective and Collective Lens

Wide-angle objective lens provides a wide field of view (approximately 180°). Light gathered by the objective lens passes through the collective lens, where the first image is formed (see figure 12-4).

12-21. Power Change Lens

The power change lens (see Figure 12-4) can be moved in and out of the optical path by means of a mechanical linkage. The mechanical linkage is actuated by the magnification changer (see Figure 12-1). For low power periscope operation, the power change lens is moved out of the optical path; while for high power operation, the lens is moved into the optical path.

12-22. SATELLITE CLOCK

The specification satellite clock is an electro-mechanical timing device located above and to the right of the periscope display assembly. The satellite clock will indicate time of day, TIME FROM LAUNCH, TIME TO RETROGRADE and RETROGRADE TIME (see Figure 12-5). The time of day will be reflected by a manually wound spring-driven movement watch. The manually wound watch is located in the upper left-hand corner of the satellite clock. Time From Launch, Time To Retrograde, and Retrograde Time will be displayed on drum counters (digidial). The drum counters will indicate time in hours, minutes and seconds. The time elements will move in one step increments. The Time To Retrograde digidial will be supplemented by a telelight, located in the upper right-hand corner of the satellite clock, which will illuminate 5 minutes prior to retrograde time; in addition to the telelight, an aural signal to the Astronaut's headset is initiated 10 seconds prior to retrograde time. The satellite clock is automatically started by 28V d-c power at liftoff. Should this not occur, a push button switch is provided above and adjacent to the clock to allow the Astronaut to energize the clock (and maximum altitude sensor) manually. The retrograde time is normally computed and set prior to flight, but the retrograde time can be manually changed by the Astronaut (retrograde time reset handle) or remotely set through the command receivers. Ten minutes prior to retrograde time, the

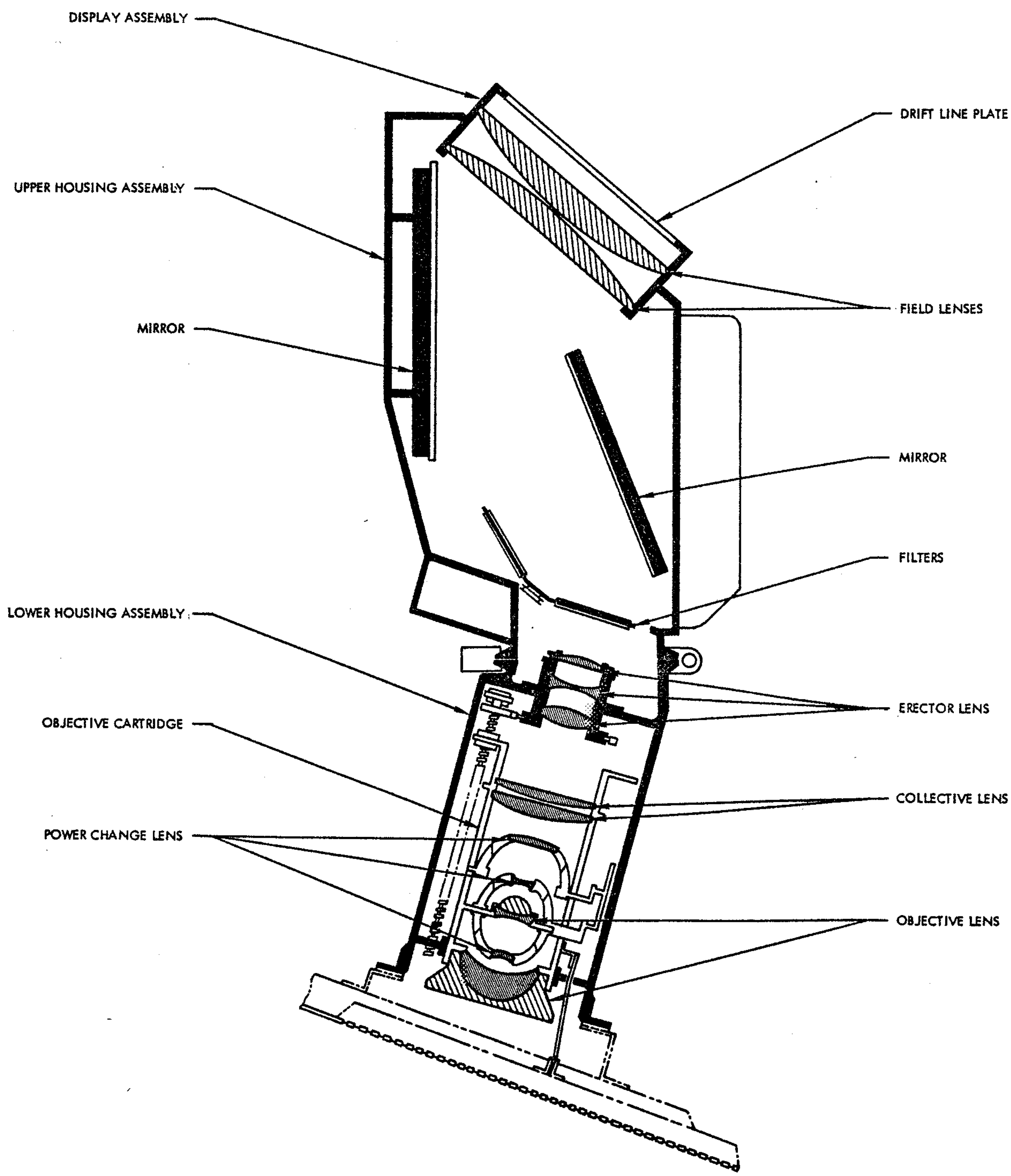


FIGURE 12-4 OPTICAL SYSTEM SATELLITE PERISCOPE

PM45-262

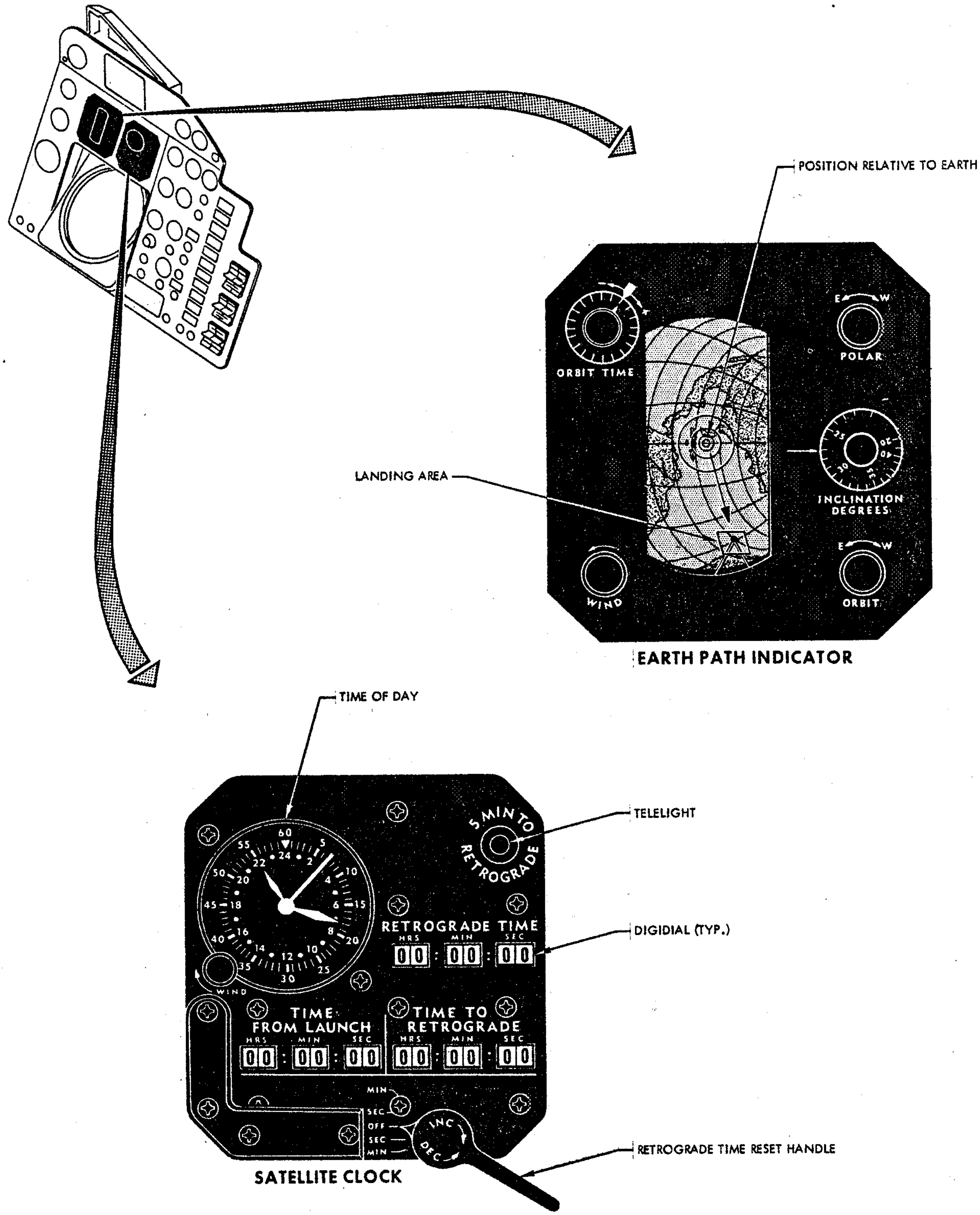


FIGURE 12-5 EARTH PATH INDICATOR AND SATELLITE CLOCK

PM45-113B

satellite clock transmits a signal to the ASCS to start horizon scanners operating continuously and assures rate gyro operation in preparation for retro sequence. Upon reaching retrograde time, a set of contact points within the clock close, initiating the retrograde sequence. Time From Launch and Retrograde Time digidials provide outputs for telemetering.

12-23. EARTH PATH INDICATOR

The earth path indicator (see Figure 12-5) consists of a spherical map (globe) of the earth gimballed and rotating in a manner to indicate ground position under the capsule. The indicator is spring motor powered and is capable of running 20 hours without re-winding. The globe, which is approximately 3.85 inches in diameter, will display the following geographical features:

(1) All continents

(2) All bodies of water having major dimensions of 300 statute miles

(3) The sixteen largest rivers of the world

(4) All islands having major dimensions of 500 statute miles

(5) All known islands or island clusters separated from continents by 300 statute miles and having major dimensions less than 500 statute miles shall be identified by an .020 diameter circle.

(6) The fifty largest cities of the world are identified by .020 dots.

(7) 15° latitude and longitude lines are presented and numbered.

Controls are provided on the face of the indicator to wind the spring motor and to adjust the orbit time, adjust orbit inclination and to slew the globe about the earth and the orbital axis. The touchdown area is displayed as a rectangle and the luminous dot inside of the rectangle being the point of impact. The landing area is 3040 nautical miles ahead of instantaneous orbital position above the earth as indicated by the four ring bullseye. The instrument is externally lighted by cabin floodlights.

12-24. ALTIMETER

The altimeter visually indicates external pressure above sea level. (See Section I for location.) It is a single revolution type, calibrated from 0 to 100,000 feet, with a marker at 10,000 (MAIN) and 20,000 (SNORKEL). Static pressure is obtained from a centrally located plenum chamber which connects to four static ports spaced equally around the small end of the capsule conical section. The instrument is lighted externally by cabin floodlights.

12-25. LONGITUDINAL ACCELEROMETER

The accelerometer is a self-contained unit which is housed in a hermetically sealed inclosure. (See Section I for location.) The accelerometer is designed to indicate acceleration in the range 0 to -9 and 0 to +21 g units (acceleration of 32.2 feet per second per second). Attached to the face of the accelerometer are three pointers. One pointer will indicate instantaneous acceleration. The remaining two pointers are memory pointers. One memory pointer will record positive acceleration and the other will record negative acceleration. The memory pointers will incorporate a ratchet device which will maintain a deflection until they are reset by means of a reset knob which is located in the lower left hand corner of the accelerometer.

12-26. HAND COMPUTER

The satellite hand computer (see Figure 12-6), physically resembling a circular slide rule, is provided to aid the Astronaut in solving navigation problems. The computer consists of three discs; a basic fixed disc, a small top fixed disc and a rotating intermediate disc. The computer is stowed in the Astronaut's map case. The computer may be used to find orbital tangential velocity, orbital angle, drift, true ground speed, indicated ground speed, and for multiplication, division and proportions. Operation of the computer is as

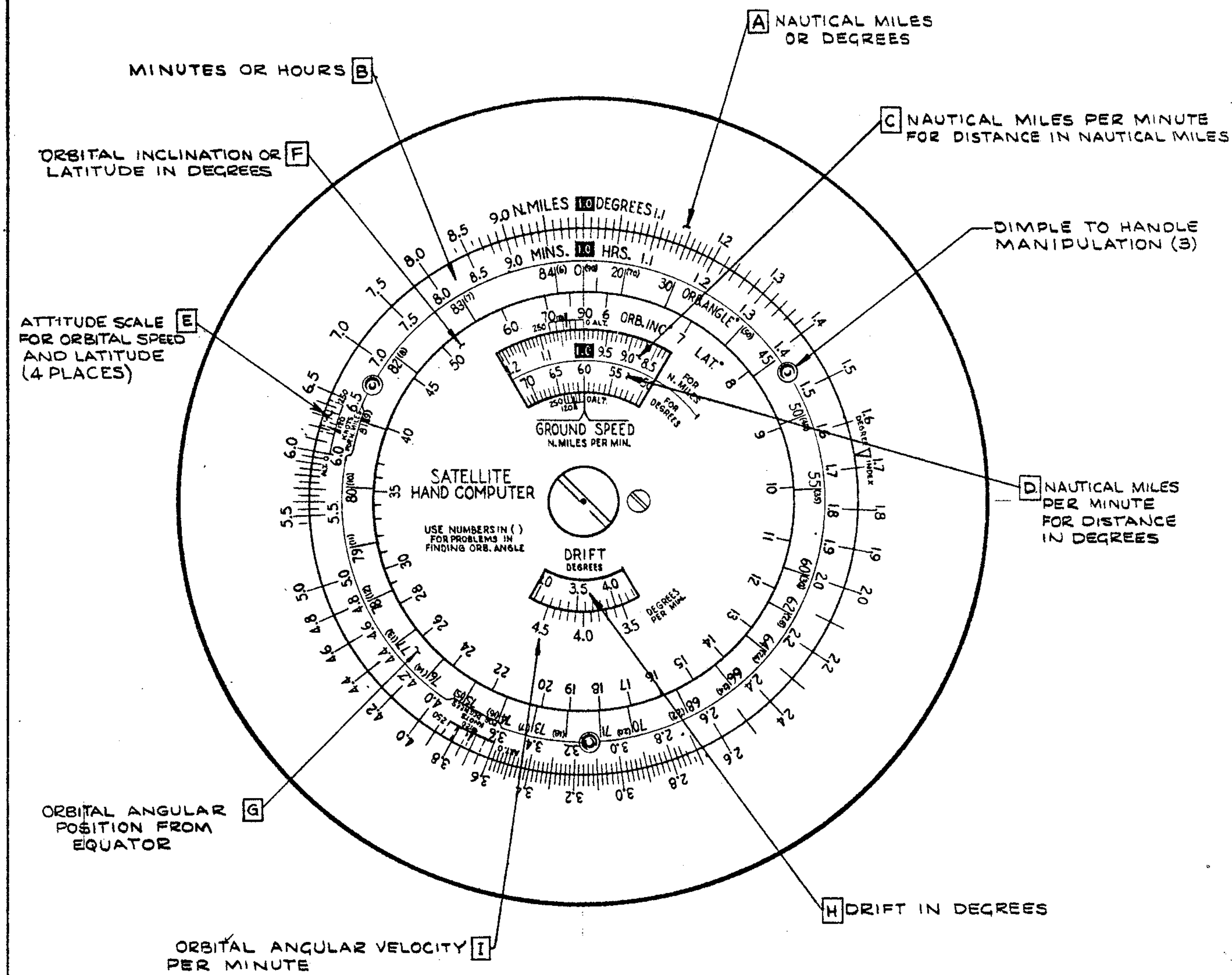


FIGURE 12-6 HAND COMPUTER

follows:

12-27. Orbital Tangential Velocity

A. To compute orbital tangential velocity when ground distance, altitude (nautical miles) and time (minutes) are known, proceed as follows:

(a) Set the time on scale B opposite the ground distance on scale A.

(b) Read orbital tangential velocity in nautical miles per minute on scale C opposite the altitude.

(c) Read orbital tangential velocity in knots (nautical miles per hour) on scale A opposite the altitude (at 6.0 on scale B).

I. Sample Problem

Given:

ground distance = 2880 nautical miles (N.M.)

time = 12 minutes

altitude = 120 N.M.

Required: Orbital tangential velocity in N.M. per minute and orbital tangential velocity in N.M. per hour.

Operation:

(1) Set the time 12 (1.2) minutes on scale B opposite the ground distance 2880 (2.88) N.M. on scale A.

(2) Read orbital tangential velocity 248.39 N.M./min. on scale C at 120 on the altitude scale.

(3) Read orbital tangential velocity 14,903.4 N.M./hr. on scale A opposite 120 on altitude scale (at 6.0 on scale B).

B. To compute orbital tangential velocity when angular position in degrees, time in minutes and altitude in nautical miles are known, proceed as follows:

(a) Set the time on scale B opposite angular position on scale A.

(b) Read orbital tangential velocity in nautical miles per minute (N.M./min.) on scale D.

(c) Read orbital tangential velocity in N.M./hr. on scale A opposite altitude on altitude scale (at 3.6 on B scale).

II. Sample Problem

Given:

angular position = 48 degrees

time = 12 minutes

altitude = 120 N.M.

Required: Orbital tangential velocity in N.M./min. and orbital tangential velocity in N.M./hr.

Operation:

(1) Set the time 12 (1.2) min. on scale B opposite angular position 48 degrees (4.8) on scale A.

(2) Read orbital tangential velocity 248.39 N.M./min. on scale D.

(3) Read orbital tangential velocity 14,903.4 N.M./hr. on scale A opposite 120 on the altitude scale (at 3.6 on scale B).

C. To compute orbital tangential velocity when ground speed in nautical miles per minute (N.M./min.) and altitude in nautical miles are known, proceed as follows:

(a) Set the altitude zero (0) on the E scale opposite the ground speed on the scale A.

(b) Read orbital tangential velocity on scale A opposite altitude on scale E.

III. Sample Problem

Given:

ground speed = 239.6 N.M./min.

altitude = 120 N.M.

Required: Orbital tangential velocity in N.M./min.

Operation:

(1) Set altitude zero (0) on scale E opposite the ground speed 239.6 (2.396) N.M./min. on scale A.

(2) Read the orbital tangential velocity 248.00 N.M./min. on scale A opposite altitude 120 N.M. on scale E.

NOTE

Conversion of orbital tangential velocity to ground speed is the same as the above procedure but in reverse. Set altitude on scale E opposite orbit tangential velocity on scale A then read ground speed on scale A opposite zero (0) altitude on scale E.

12-28. Orbital Angle

A. To compute orbital angle when ground distance in nautical miles (N.M.) is known, proceed as follows:

(a) Set 1.0 of scale B opposite the degree index mark (located at 1.67) of the A scale.

(b) Read orbital angle on the A scale opposite the distance on the B scale.

I. Sample Problem

Given:

ground distance = 2880 N.M.

Required: Corresponding orbital angle

Operation:

(1) Set 1.0 of B scale opposite degree index mark (located at 1.67) of the A scale.

(2) Read equivalent orbital angle of 48 degrees on scale A opposite the distance 2880 (2.88) N.M. on the B scale.

NOTE

The procedure is the same for finding ground distance when the orbital angle is known. Set 1.0 on B scale opposite degree index mark on A scale then opposite to any degree on the A scale the equivalent ground distance is read on the B scale.

B. To calculate orbital angle when latitude and orbital inclination are known, proceed as follows:

NOTE

The G scale has two sets of numbers. The plain numbers, increasing clockwise, are used for computing drift while the numbers in parenthesis, increasing counterclockwise, are used for computing orbital angle.

(a) Set zero (0) of G scale opposite latitude on F scale.

(b) Read orbital angle on G scale opposite orbital inclination on F scale.

II. Sample Problem

Given:

ground latitude = 14 degrees 29 minutes

orbital inclination = 30 degrees

Required: Orbital angle

Operation:

(1) Set zero (0) of G scale opposite latitude 14° 29' on F scale.

(2) Read orbital angle (30°) on G scale opposite orbital inclina-

tion 30° on F scale.

C. To compute latitude when orbital angle and orbital inclination are known, proceed as follows:

(a) Set orbital angle on G scale opposite orbital inclination on F scale.

(b) Read latitude on F scale opposite zero (0) on G scale.

D. To compute angle of inclination when latitude and orbital angle are known, proceed as follows:

(a) Set zero (0) of G scale opposite latitude on F scale.

(b) Read orbital inclination on F scale opposite orbital angle on G scale.

12-29. <u>Drift</u>

A. To compute drift when orbital inclination, orbital angle in degrees and orbital velocity in degrees per minute are known, proceed as follows:

(a) Set the orbital angle on the G scale opposite the angle of inclination on the F scale.

(b) Read the drift in the lower window opposite the orbital angular velocity on the I scale.

I. Sample Problem

Given:

orbital inclination = 32°

orbital angle = 0°

orbital angular velocity = 4°/min.

Required: Drift

Operation:

(1) Set orbital angle 0° on the G scale opposite 32° angle of inclination on the F scale.

(2) Read drift 1.897° in lower window opposite 4° orbital angular velocity on the I scale.

12-30. Orbital Ground Speed

A. To compute orbital ground speed, we must first find the effective component of the earth's tangential velocity and then add it to the indicated ground speed. To find the earth's tangential velocity component, the following must be known: Orbital inclination, orbital angle and the earth's tangential velocity at the equator. When the above information is available, proceed as follows:

NOTE

In the following presentations, the F and G scale is not used according to their designation. They are to be used as directed.

(a) Set the orbital inclination on the G scale opposite 90 degrees (zero degrees) on the F scale.

(b) Read effective component of earth's tangential velocity on the A scale opposite the earth's tangential velocity at the equator on the B scale.

(c) Orbital ground speed will be indicated ground speed plus effective component of earth's tangential velocity.

I. Sample Problem

Given:

earth's tangential velocity at the equator	=	15 N.M./min.
orbital inclination	=	30 degrees
orbital angle	=	0 degree
indicated ground speed	=	240 N.M./min.

Required: Orbital ground speed.

Operation:

(1) Set the orbital inclination 30 degrees on the G scale opposite orbital angle zero degrees (90 degrees) on the F scale.

(2) Read effective component of earth's effective tangential velocity 12.99 (1.299) N.M./min. on the A scale opposite the earth's tangential velocity at the equator 15 (1.5) N.M./min. on the B scale.

(3) Orbital ground speed = indicated ground speed (240 N.M./min.) plus effective component of earth's tangential velocity (12.99) or 252.99 N.M./min.

NOTE

Effective earth velocity is constant; orbital ground speed for all practical purposes can also be considered constant for any given orbit.

12-31. ATTITUDE-RATE INDICATOR

The Attitude-Rate indicator is a three axis angular rate and attitude indicating system located approximately at the top center of the main instrument panel. It is designed to indicate attitude and the rate of change of attitude. The unit is a composite arrangement consisting of a rate indicator around which are positioned a roll attitude indicator, a yaw attitude indicator and a pitch attitude indicator (see Section I, Figure 1-15). The rate indicator will display three pointers. The rate of roll pointer is the pointer which is parallel to the pointer of the roll attitude indicator. The rate of yaw and rate of pitch pointers are pointed towards the yaw and pitch attitude indicators respectively. All components are completely interchangeable. The failure of one component will not necessitate recalibration or replacement of allied components. The attitude-rate indicator is activated by pitch rate, roll rate and yaw rate transducers. Each transducer consists of a gyroscope, an amplifier and a demodulator. These components function together to produce a d-c output signal proportional to the input rate of change of attitude.

12-32. NAVIGATIONAL AID KIT

The navigational aid kit consists of a neoprene coated nylon case, a binder assembly and a computer board. It is mounted to the periscope directly below the circular display area (see Figure 12-1, Sheet 1 of 2). The binder assembly consists of a number of index cards. The index cards will be used to file check lists, rate cards and navigational charts that shall be provided as required by the particular capsule mission. The following items are attached to the binder assembly: Pencil holder, mechanical pencil and nylon retention springs. The pencil holder is fabricated from neoprene coated nylon and is sewn to the case. The mechanical pencil is secured to the binder assembly by means of a nylon retention spring. A nylon retention spring also secures the binder assembly to the neoprene coated nylon case. A computer board, which is constructed from the hand computer (see Figure 12-4), forms a part of the navigational aid kit.

12-33. TEST CONFIGURATION CAPSULES

12-34. TEST CONFIGURATION CAPSULES 8, 9, 10, 13 AND 16

12-35. General

Capsules 8, 9, 10, 13 and 16 are fundamentally the same as the specification capsule. Some differences will exist in the location of the various instruments. (See Section I for instrument panel illustration.) Other differences are enumerated in the following paragraphs.

12-36. Periscope

Capsule 8 periscope system will not incorporate a RETRACT SCOPE telelight and the associated MAN-AUTO periscope retract switch. Capsules 9, 13 and 16 will have provisions for telemetering periscope door closure. Before ground operation of periscope, observe operational instructions attached to the navigational aid kit (see Figure 12-1). Equipment in the periscope upper housing assembly in Capsule 9 has been removed to faciliate installation of an internal camera (see Figure 12-7).

12-37. Altimeter

The altimeter used in Capsule 8, 9, 10, 13 and 16 have markings at the 20,000 and 10,000 foot levels to indicate when the snorkel valves and main parachute, respectively will actuate. Along the outer edge of the instrument dial starting at 0 feet and advancing to 28,000 feet are psia indications which are as follows: 0 feet 15 psia, 10,000 feet 10 psia and 28,000 feet 5 psia.

12-38. Longitudinal Accelerometer

Capsules 8 and 9 will not have memory pointer or a reset mechanism. The location may vary with each capsule depending on planned mission. (See Section I for instrument panel illustration.)

12-39. Hand Computer

Only manned capsules will be equipped with the hand computer.

12-40. Attitude-Rate Indicator

NOTE

External appearance of attitude-rate indicator display is the same for all capsules except for color of pointers and as follows:

On Capsule 9, the pitch dial of the display mates with the zero pitch rate index at -43 degrees.

On Capsules 8, 10, 13 and 16, the pitch dial of the display mates with the zero pitch rate index at -34 degrees.

12-41. Navigational Aid Kit

Capsules 8, 9 and 13 will not contain a navigational aid kit.

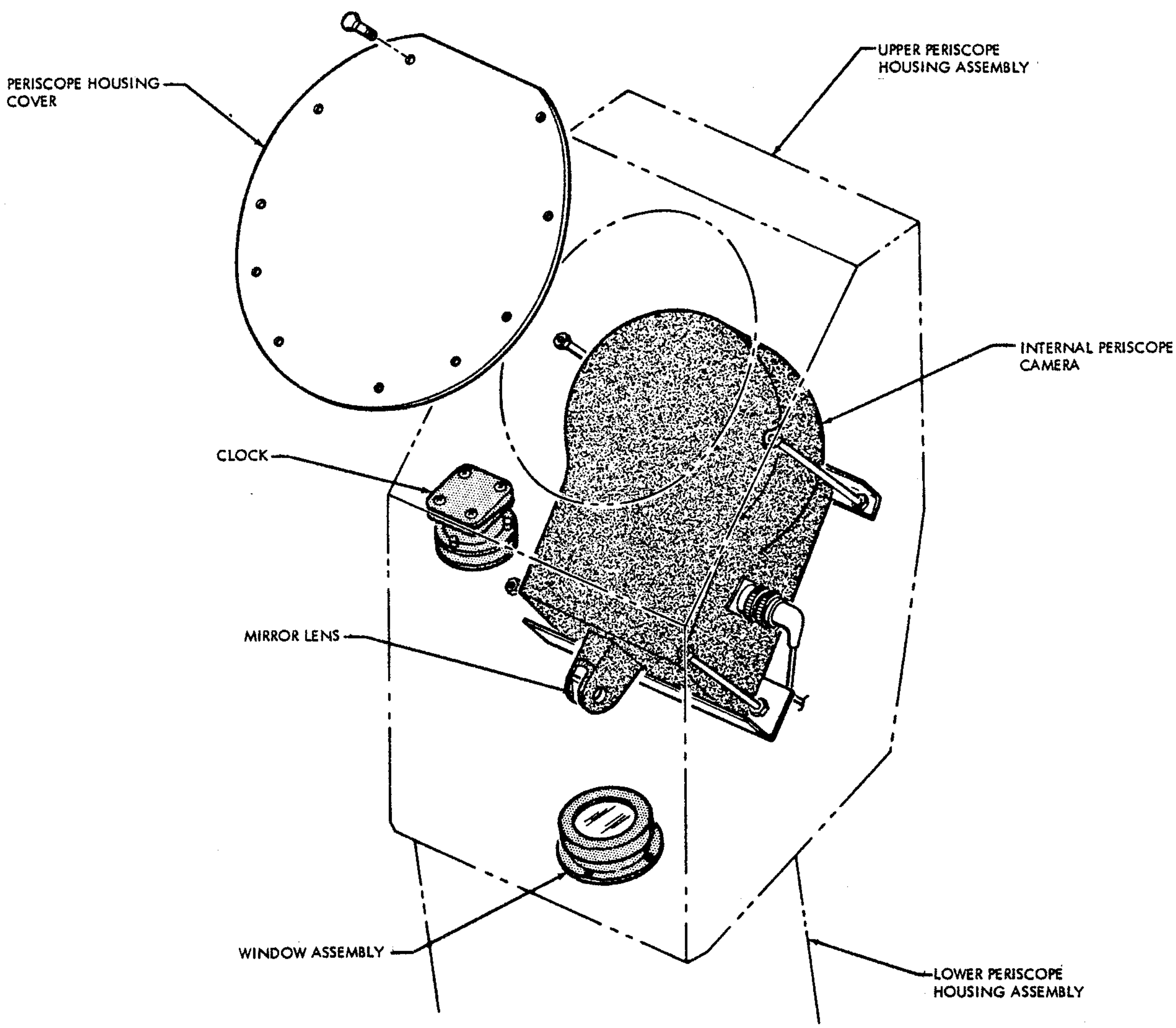
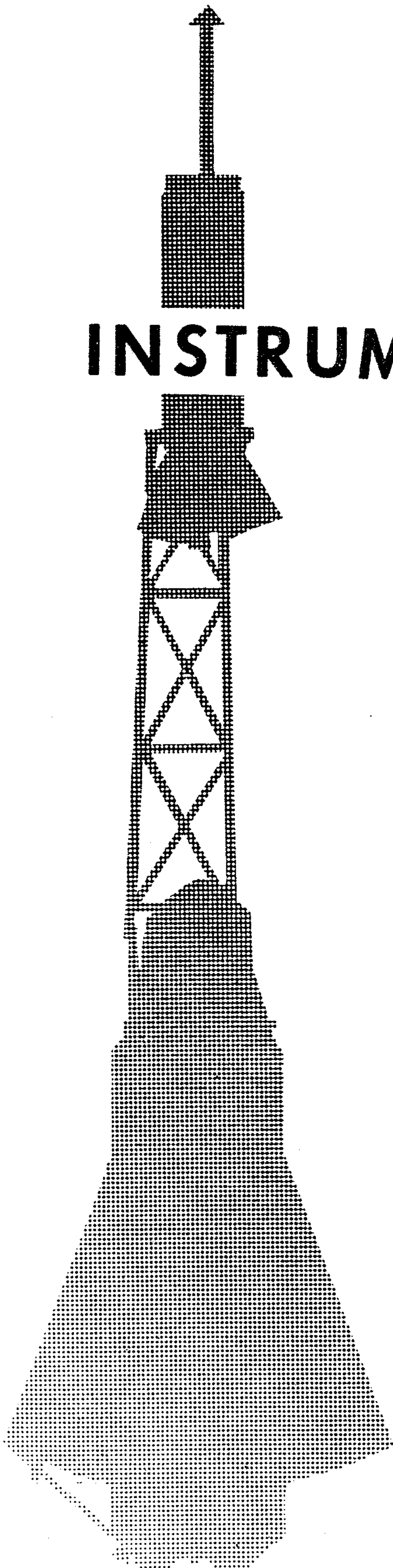


FIGURE 12-7 INTERNAL PERISCOPE CAMERA (CAPSULE 9 ONLY)

PM45-272

SECTION XIII



INSTRUMENTATION SYSTEM

TABLE OF CONTENTS

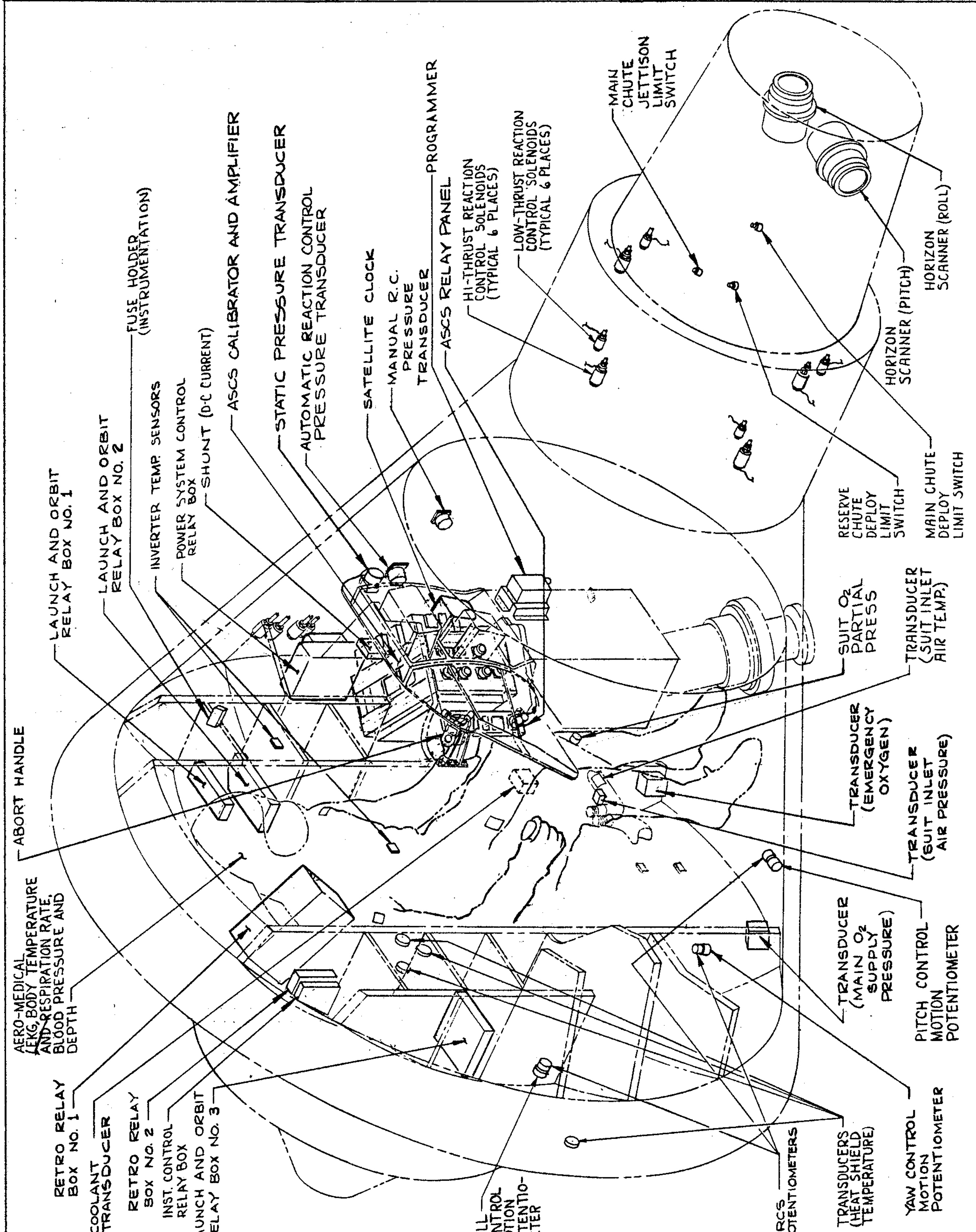


FIGURE 13-1 INSTRUMENTATION SYSTEM (CAPSULES 10,13,16,18 & 19) SHEET 1 OF 2)

PM45-129E-1

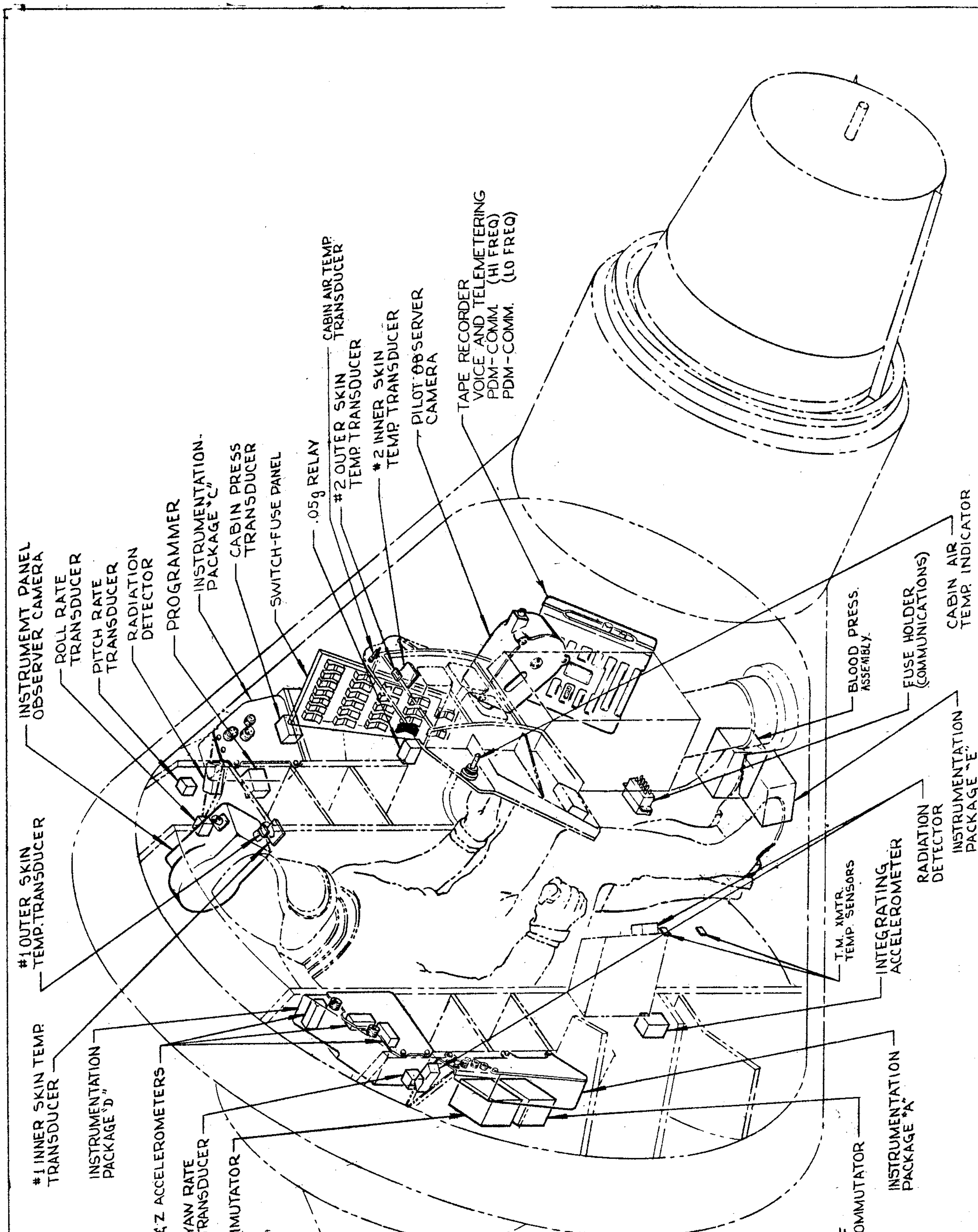


FIGURE 13-1 INSTRUMENTATION SYSTEM (CAPSULES 10, 13, 16, 18 & 19) (SHEET 2 OF 2)

PM45-129 E-2

XIII. INSTRUMENTATION SYSTEM

13-1. SYSTEM DESCRIPTION

The instrumentation system consists of the major components as shown on Figure 13-1. These components coupled with various transducers and other pickup devices provide a means of monitoring the physical condition and reactions of the Astronaut as well as capsule conditions and systems performance. The data so obtained is coded and applied to the telemetry transmitters and radiated to ground stations for immediate analysis and evaluation; it is also recorded on a tape recorder in the capsule for subsequent study and interpretation. Cameras are installed and so positioned to record the Astronaut's facial expressions and to provide a chronological record of the instrument readings on the main instrument panel. Provisions are also provided for automatic programmed control over some components not intended for continuous operation.

13-2. SYSTEM OPERATION

The instrumentation system is completely automatic in operation from the time power is applied to the capsule until 10 minutes after landing impact, however, certain components may be controlled or interrogated during flight by either the Astronaut or ground command. The instrumentation system is divided into three groups, namely, monitoring, control and recording. These three groups are treated individually in paragraphs 13-3, 13-59 and 13-63.

13-3. MONITORING

Instrumentation monitoring consists of sampling values of pressures, temperatures, conditions and operations of various units and functions throughout the capsule; these samples are converted into signals composed of voltages proportional to the temperature, pressure and conditions being measured. The proportional voltages are calibrated within common maximum and minimum ranges to provide zero to full scale readings. These signals are then channeled into either or both of the two commutators (electronic switches) designated High Frequency and Low Frequency, which are located in Instrumentation Package "A". The majority of the signals are fed to both "HF" and "LF" Commutators for redundancy. Each commutator continuously samples its input Channels, combining the signal voltage pulses into a pulse train for each commutator. The pulse train from the HF Commutator and the LF Commutator is applied to separate but identical 10.5 Kc voltage controlled subcarrier oscillators, where the changing voltage of the pulse train vary the frequency of the oscillators. The output of this and other voltage controlled oscillators driven by aero-medical information are mixed and used to modulate the telemetry transmitters. The HF Commutator signals are telemetered through the high frequency transmitter while the LF Commutator signals use the low frequency set. Both the HF and LF Commutator signals are also converted to pulse duration signals and recorded on a tape recorder in the capsule.

Figure 13-2 is a block diagram showing the parameters of the instrumentation that is monitored as well as the Commutator Point assignments with a brief explanation of each parameter given in paragraphs 13-4 through 13-58.

13-4. <u>Capsule Electrical Power</u>

Capsule electrical power system instrumentation consists of monitoring the circuit illustrated on Figure 13-2.

13-5. 400 cps Monitor

ASCS and fan bus 115 volt a-c is applied thru two 115/6.3 volt transformers in Instrumentation Package "A" and "E". The secondary outputs are rectified, filtered and attenuated prior to being applied to the commutators as a zero to three volt d-c signal. A three volt signal (full scale) represents 120 volts

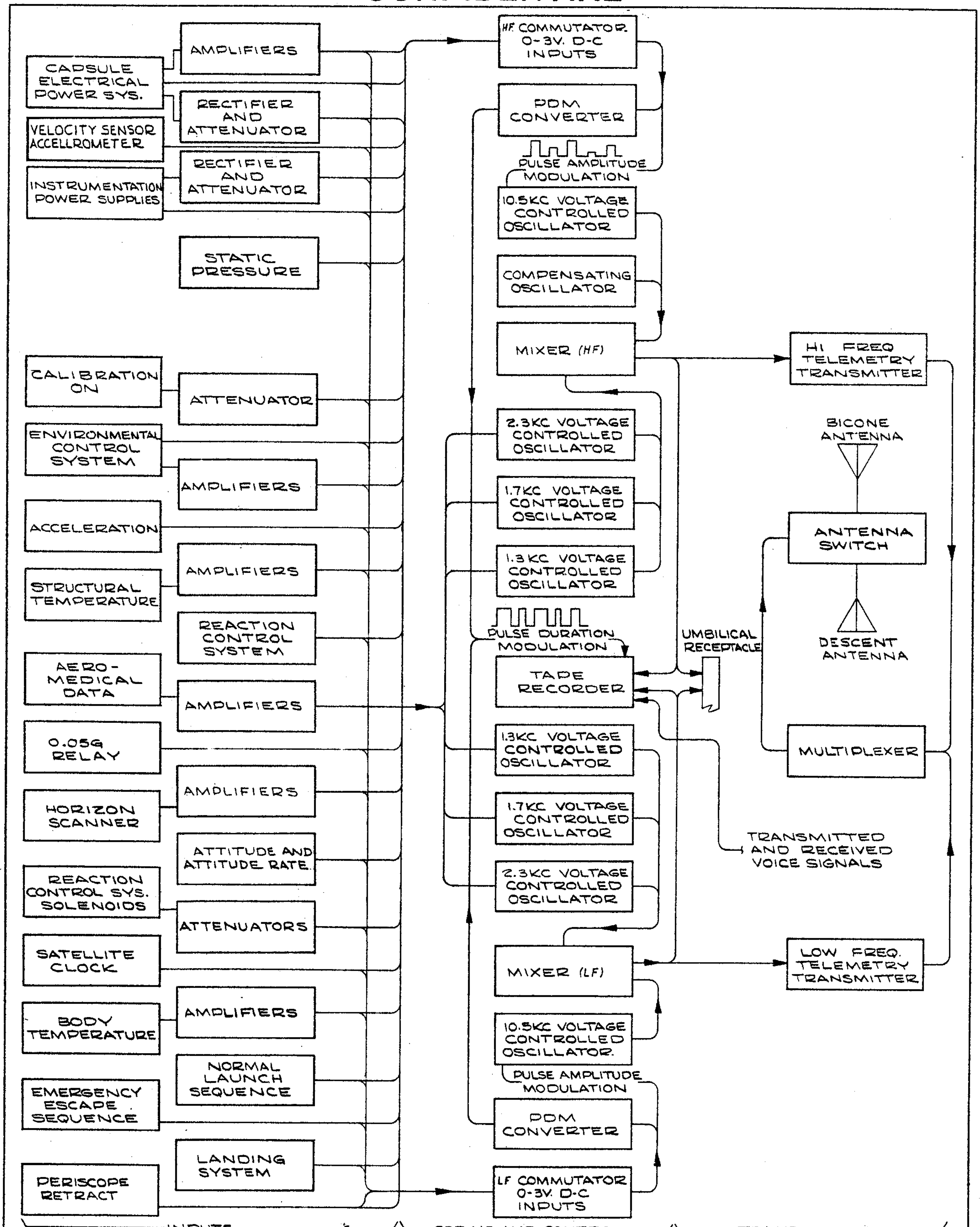


FIGURE 13-2 MONITORING INSTRUMENTATION BLOCK DIAGRAM-(CAPSULES 18 & 19)

PM45-130E

for each bus.

13-6. D-C Current

D-c current amplitude is sensed by the shunt for the instrument panel ammeter. This shunt is in the negative lead of all capsule batteries and senses total battery current. The voltage across the shunt is 50 millivolts when 50 amperes are flowing. This voltage is applied to two d-c amplifiers in package "C" which amplifies it to a zero to three volt level. A three volt level (full scale) represents 50 amperes battery current. The output of one amplifier is applied to the HF Commutator, and the other amplifier output is applied to the LF Commutator.

13-7. D-C Voltage

The 24 volt d-c monitor circuit is made up of a voltage divider network in package "A". Voltage from the main pre-impact 24 volt d-c bus is applied to this divider. A three volt signal (full scale) represents 30 volts bus voltage. The 18 volt d-c isolated bus and the 18 volt d-c standby busses are similarly monitored through voltage divider networks located in the "E" package.

13-8. Standby Inverter

The standby inverter on signal is obtained through normally open contacts of the standby inverter relay. This relay energizes when either of the main inverters fails. With the relay energized, 24 volts d-c is applied to an attenuator in the power and control relay box. Attenuator output (2.2 volts d-c, nominal) is applied to the commutators.

13-9. Instrumentation Power Supplies

Instrumentation power supplies instrumentation consists of the monitor circuits for the 3 volt d-c reference, zero reference, and 7 V 400 cps power supplies. (See Figure 13-2.)

13-10. Three Volt Reference

The 3 volt d-c reference power supply furnishes excitation for all potentiometer type instrumentation pick-ups. The power supply is located in package "A". It is a zener diode regulated supply from the 24 volt bus. The output from the power supply is applied directly to the commutators and serves as a reference full scale signal.

13-11. Zero Volt Reference

The zero reference signal is signal ground and is also the return for the 3 volts d-c reference power supply output. This signal is also applied to the commutators.

13-12. Seven Volt 400 cps

The 7 volt 400 cps power supply furnishes excitation for the input bridge circuits utilized with the resistance element amplifiers. Power supply output is rectified, filtered and attenuated to a zero to three volt level. This zero to three volt signal is applied to the commutators. A three volt signal (full scale) represents a 7 volt output level. The power supply is a transistorized power inverter which operates on 24 volts d-c to provide the 7 volt 400 cps output. It is located in package "A".

13-13. Calibration On

Calibration ON instrumentation consists of a circuit which monitors presence of the full scale and zero scale calibration command signals. This signal is present when the CALIBRATION switch in the telemetry trailer is placed to "FULL SCALE" or "ZERO" position. When the full scale calibrate command is present, 24 volts d-c is applied to an attenuator in package "C". The output of the attenuator (2.8 volts d-c, nominal) is applied to the commutators. When the zero scale calibrate command is present, 24 volts d-c is applied to a different input point on the same attenuator network. The output of the attenuator (1.5 volts d-c, nominal) is applied to the commutators. Thus, an upper scale signal indicates presence of the full scale calibrate command and a half-scale signal indicates presence of the zero scale calibrate command. These command signals energize relays which apply calibrate signals to numerous other instrumentation channels. The "R" and "Z" calibrate function may be initiated from a ground station through the command receivers while in orbit.

13-14. Static Pressure

Static pressure instrumentation consists of a potentiometer type transducer which is operated by static pressure. The potentiometer is excited with 3 volts d-c from the instrumentation power supply and wiper voltage output is inversely proportional to static pressure. A three volt signal (full scale) is representative of 0 psia.

13-15. Environmental Control System

Environmental control system instrumentation consists of circuitry which monitors primary and secondary oxygen supply pressures, suit inlet air pressure and temperature, cabin pressure and temperature and coolant quantity.

13-16. Suit O_2 Partial Pressure

O_2 partial pressure is sensed by a transducer in the Astronaut's suit, the signals are amplified and transmitted to a pressure gage on the instrument panel. The signals are also applied to the "HF" and "LF" commutators in Instrument Package "A" where they are converted to PAM and PDM signals. The PAM signals are telemetered to ground and the PDM signals are recorded on the capsule tape recorder.

13-17. Oxygen Supplies

Primary and secondary oxygen supply pressures are sensed by pressure actuated dual potentiometers in the environmental area. One potentiometer operates a panel indicator while the other wiper picks off a value for instrumentation. Wiper voltage output is linearly proportional to pressure. Excitation is applied from the 3 volt d-c instrumentation power supply. The zero to 3.00 volt wiper output represents a pressure range of zero to 7,500 psi with 0 to 100% meter indications. Outputs from the primary and secondary oxygen supply pressure transducers are applied to both commutators.

13-18. Suit Inlet Temperature

Suit inlet air temperature is sensed by two resistance element transducers in the suit inlet air line. Transducer resistance varies proportionally with temperature. Each transducer is part of a bridge input circuit to an amplifier in package "A". The zero to three volt (full scale) output from the amplifier is representative of a temperature range of 35° to 100°F. One amplifier output is applied to the HF Commutator; the other amplifier output is applied to the LF Commutator.

13-19. Suit Inlet Pressure

Suit inlet air pressure instrumentation consists of a potentiometer type transducer which is pressure actuated. The potentiometer is excited with 3 volts d-c from the instrumentation power supply and wiper voltage output varies linearly with pressure. The zero to three volt (full scale) output represents a pressure range of zero to 15 psia and is applied to both commutators.

13-20. Cabin Pressure

Cabin pressure instrumentation consists of a potentiometer type pressure transducer installed in package "C". The potentiometer is excited with 3 volts d-c from the instrumentation power supply and wiper voltage output is linearly proportional to cabin pressure. The zero to three volt (full scale) output from the wiper represents a pressure range of zero to 15 psia.

13-21. Cabin Air Temperature

Cabin air temperature is sensed by two platinum resistance wire transducers mounted in package "A". Transducer resistance varies proportionally with temperature. Each of the transducers is part of a bridge input circuit to an amplifier in package "A". The zero to three volt (full scale) output from the amplifier is representative of a temperature range of zero to 200°F. Amplifier outputs are applied to the HF and LF Commutators.

13-22. Coolant Quantity

Coolant quantity is measured by sensing the pressure of the oxygen bottle used to force water from the coolant tank. This bottle supplies five hundred pounds pressure. As coolant quantity decreases, the confined volume of the oxygen increases with a resulting decrease in oxygen pressure. A pressure potentiometer excited by three volts d-c from the instrumentation power supply monitors oxygen pressure. Wiper output is applied to the HF and LF Commutators and through an attenuator in package "A" to the coolant quantity indicator. Zero to three volt (full scale) covers a range of zero to 100% coolant quantity. Oxygen pressure at 100% coolant quantity is 480 psi, oxygen pressure at 0% coolant quantity is 230 psi.

13-23. Reaction Control System

Reaction control system instrumentation consists of monitors for automatic and manual reaction control supply pressure and Astronaut hand control position.

13-24. Horizon Scanner

Horizon scanner instrumentation monitors for the pitch and roll horizon scanner outputs and ignore signals for each of these outputs.

The horizon scanner system utilized two identical infra-red scanning units to provide pitch and roll reference signals. The Horizon Scanners are on continuously, from launch until re-entry at which time the Scanners are de-activated by the 0.05g relay but during the orbital phase the reference signals are applied to the ASCS attitude gyros only upon command from the programmer. (Refer to

Table 13-1.) The signals that are applied to the gyros are monitored by instrumentation. The pitch and roll signals range between ± 10 volts d-c. These signals are applied to a biased attenuator card to provide a zero to 2.68 volt output which is coupled to separate channels of the HF Commutator. The signals represent an output range of ± 35°.

Occasionally a scanner sweeps across the sun. Since the scanners are infrared devices, sweeping of the sun introduces error voltage. To prevent utilization of this voltage, the scanner supplies an "ignore" signal to the ASCS. This "ignore" signal is monitored as an on-off type of signal by instrumentation. Pitch ignore and roll ignore signals are applied to the HF Commutator only. A half scale signal represents presence of the pitch ignore signal and full scale level indicates presence of the roll ignore signal.

13-25. Attitude

Attitude instrumentation consists of telemetry channels which monitor capsule pitch, roll and yaw attitudes. Each attitude is read out of a synchro actuated potentiometer. The synchros are driven by the automatic stabilization control system. Excitation for the potentiometers is furnished by the three volt d-c instrumentation power supply. Signal voltage varies along a multiple slope function with capsule attitude. Pitch and roll signals cover a range of +130° to -190°. Yaw signals cover a range of +70 to -250°. Each of the attitude signals is applied to separate channels of HF and LF Commutators. After retrograde assembly jettison and energizing of a 0.05g relay, the potentiometer-positioning synchros become inoperative. At this time, attitude signals are removed from the commutators and attitude rate signals are applied to the relinquished commutator channels.

13-26. Attitude Rate

Attitude rate instrumentation utilized signals from rate gyros. The gyros are part of the attitude rate indicating system. A zero to three volt signal level represents a rate level of decreasing 40° per second to increasing 40° per second. Attitude rate signals are applied to the LF Commutator. Roll, pitch and yaw rates are assigned to separate channels. In addition, attitude rates are applied to the channels normally occupied by attitude data when attitude data is no longer generated. (Refer to Paragraph 13-25.)

13-27. Reaction Control System Solenoids

The reaction control system solenoids control the thrust jets used for capsule stabilization in flight. These solenoids can be energized manually or automatically. When a solenoid is energized, 24 volts d-c is applied through an attenuator in package "C" to the HF and LF Commutators. Each of the twelve solenoids is represented by a separate commutator channel. This on-off signal is presented to instrumentation circuitry from the amplifier-calibrator in the ASCS system.

13-28. Supply Pressures - H_2O_2

The monitor circuits for reaction control supply pressures are identical in operation. A helium source of 2050 psi is utilized to expel hydrogen peroxide from a bladder. As hydrogen peroxide is expelled, the confined volume of the helium increases and helium pressure decreases. A pressure potentiometer senses this change in pressure. The potentiometer is excited with three volts from the instrumentation power supply. Wiper output voltage is applied to both commutators and through an attenuator to an indicator. Transducer range is 600 to 2200 psi. A pressure of 2050 psi provides a reading of 100% on the indicator. Hydrogen peroxide is exhausted at approximately 600 psi. helium pressure. Indicator reading at this pressure is approximately 0%.

13-29. Hand Control

Astronaut hand control position is monitored by three potentiometers. The wipers of these potentiometers are driven by linkage to the hand control. Three volts from the instrumentation power supply is utilized to excite the potentiometers. Zero to three volt signal level represents $\pm 13^{\circ}$ hand control movement in the roll and pitch planes and $\pm 10^{\circ}$ movement in the yaw plane. Wiper outputs are applied to both commutators.

13-30. Capsule Acceleration

Capsule acceleration instrumentation consists of circuitry which monitors acceleration along the mutually perpendicular axes. Three accelerometers installed in package "D" provide zero to three volt d-c outputs proportional to acceleration along the longitudinal (Nz) lateral (Nx) and normal (Ny) axes of the capsule. The accelerometer outputs are linear with a zero acceleration providing a 1.5 volt d-c signal. The longitudinal axis accelerometer covers a range of $\pm$ 30g to provide zero to three volt output signals. The normal and lateral axes accelerometers operate in two ranges. During launch and re-entry a zero to three volt signal represents accelerations between $\pm$ 4g. During orbit, a zero to three volt signal represents accelerations between $\pm$ 0.5g. These zero to three volt signals are applied to the commutators.

13-31. Velocity Sensor

The velocity sensor is designed to measure separation velocity increase during posigrade rocket firing and velocity decrease during retrograde rocket firing. During posigrade firing the integrating accelerometer will, with application of 24 volt d-c signal, integrate for $1.5 \pm {}^{3}_{0}$ seconds after a velocity of 10 ft/sec. $\pm$ 1.5 ft/sec. has been reached. At this time the maximum velocity signal will be held for approximately six (6) minutes. This signal is applied to the HF and LF Commutators as a zero to three volt value and is used to determine the separation velocity of the capsule from the preceding stage. During retrograde firing, integration will be started by application of a 24 volt d-c signal and will integrate maximum velocity for 22 ± 2 seconds after a velocity of 240 ± 40 ft/sec. has been reached. The signal will be held for 30 minutes or until impact. The integrating accelerometer will also actuate the 240 ft/sec. relay which will direct 24 volts d-c power to the Telemetry velocity sensor relay through a four and eight minute timer; the timer in turn directs the 24 volt power through various size resistors to produce a signal composed of three different values of four minutes duration each. These timed signals together with the velocity signals are applied to the HF and LF Commutators to be used to determine the approximate impact area of the capsule.

13-32. Structural Temperatures

Structural temperature instrumentation consists of monitor circuits for ablation shield, outer skin and inner skin temperatures as well as inverters, telemetry transmitters and retro-rockets.

13-33. Ablation Shield Temperatures

The ablation shield temperatures are monitored through the telemetry system. Four transducers are embedded in the inner face of the shield. The transducers have a temperature range from zero to 2000 degrees F. with a nominal resistance of 100 ohms at 70°F. Input power of 7 V d-c 400 cps applied to the transducers is attenuated to a value dependent upon the transducer resistance. The output from the transducers is directed into two identical amplifiers (two transducers to each amplifier) in package "A" where the voltage is converted and amplified to a zero to 3 V d-c signal and applied to the telemetry commentators. The amplifiers are "R" and "Z" calibrated at intervals from ground command.

13-34. Outer Skin Temperature

Outer skin temperature is sensed by two resistance element transducers welded to the inside surface of the outer skin shingles in forward and aft locations. Transducer resistance varies proportionally with temperature. Each of these transducers is part of a bridge input circuit to an amplifier in package "C". The zero to three volt (full scale) output from the amplifier is representative of a temperature range of -65 to 2200°F. The output from the amplifier associated with the aft transducer is applied to the HF Commutator. The forward transducer amplifier output is applied to the LF Commutator.

13-35. Inner Skin Temperature

Inner skin temperature is sensed by two resistance element transducers adhering to the inner skin in forward and aft positions. Transducer resistance varies proportionally with temperature. Each of these transducers is part of a bridge input circuit to an amplifier in package "A". The zero to three volt (full scale) output from the amplifier is representative of a temperature range of 0 to 300°F. The output of the amplifier associated with the aft transducer is applied to the LF Commutator. The forward transducer amplifier output is applied to the HF Commutator.

13-36. Inverter Temperatures

The 150 VA and the main 250 VA inverter temperatures are monitored through the telemetry system. A zero to 300 degrees F. transducer is attached externally on each inverter. The transducer resistance change of 133 ohms to 240 ohms is representative of a temperature change from zero to 300 degrees. Input power of 7 volts 400 cycles applied to the transducers is attenuated to a value dependent upon the transducer resistance, which in turn is controlled by the temperature,of the inverter. The output from the transducer is directed into an amplifier in package "A", where the voltage is converted and amplified to a zero to 3 volt d-c signal and applied to the telemetry commutators. The amplifier is "R" and "Z" calibrated at intervals from ground command.

13-37. Telemetry Transmitter Temperatures

Both HF and LF telemetry transmitter temperatures are monitored through the telemetry system. The transducers are the same as used on the inverters (refer to paragraph 13-36) and are attached externally on each telemetry transmitter. The processing of the temperature signal is the same as for the inverters except that the amplifier is located in "E" package.

13-38. Retro-Rocket Temperature

The retro-rocket temperature is monitored through the telemetry system. The transducer is the same as used on the inverters (refer to paragraph 13-36) and is cemented to the surface of the lower retro-rocket case. The processing of the temperature signal is the same as for the inverters except that the amplifier is located in "E" package.

13-39. Aeromedical

Aeromedical instrumentation consists of monitor circuits for electro-cardiograph, respiration signals, and body temperature.

13-40. Astronaut Blood Pressure

The blood pressure system consists of (1) an occluding cuff, (2) a pulse sensor, (3) differential transducer, (4) pressure source, and (5) a control system. The occluding cuff is attached externally to the Astronaut's pressure suit and contains a transducer which measures the differential pressure between the cuff and the capsule cabin pressure. The pulse sensor is a small transducer attached to the Astronaut's skin. The pressure source is a separate oxygen bottle containing sufficient oxygen to provide 150 cycles of operation during the mission. The system measures the Astronaut's blood pressure, converts the pressure to a corresponding electrical signal which is then applied to the 2.3 Kc voltage controlled oscillators and transmitted by the Hi and Lo telemetry transmitters.

The blood pressure system may be put into operation either by an "R" calibrate signal initiated from ground command or by the Astronaut actuating a "start" switch on the instrument panel. In either case, a 24 vdc pulse of five seconds duration, causes the system to pressurize to 4.4 psi differential pressure from the pressure source. After pressurizing the system bleeds off at a linear rate to 0.75 psi in approximately 22 seconds. The output signal from the pulse sensor is routed through the pressure suit disconnect and mixed with the differential pressure signal in a superimposing manner. This combined signal is routed through a relay and relay contacts to the two 2.3 Kc VCO's located in "D" package, and then to the Hi and Lo telemetry transmitters. Directing the signal through the relay is necessary in order to share the 2.3 Kc VCO's with the EKG signals.

The first appearance of the signal indicates systolic pressure with a minimum peak amplitude of 150 mv while the last occurrence of the pulse signal indicates diastolic pressure with a minimum peak amplitude of 150 mv. The maximum pulse pressure is 1 volt peak.

Upon completion of the cycle the system will remain at rest (below 3/4 psi pressure) for 10 seconds, after which time the cycle will repeat. If the system is manually (Astronaut) initiated, operation will continue for 6 ± 1 minutes or approximately 10 cycles unless manually interrupted by the "stop" switch on the instrument panel. A light on the panel indicates when the system is operating.

13-41. Astronaut EKG

Electrocardiograph signals are obtained from four transducers attached to the Astronaut's right and left side, and on the upper and lower chest. The outputs from the transducers are applied to two amplifiers in "D" package (left and right side paired to one amplifier and upper and lower chest paired to the other). Signals from the amplifiers are then directed to the 2.3 Kc and 1.7 Kc voltage controlled oscilators, which in turn apply their outputs to the Hi and Lo telemetry transmitters. The 2.3 Kc VCO's input signals are divided between the Astronaut's EKG and blood pressure outputs.

13-42. Respiration Rate

The Astronaut's breathing rate and depth is monitored through the telemetry system. A thermistor is mounted inside the Astronaut's helmet, adjacent to the microphone. Input power of 3 vdc applied to the thermistor is attenuated proportionally to the changing resistance of the thermistor, which in turn is proportional to the magnitude of the Astronaut's respiration. The respiration rate is determined by the frequency of the Astronaut's breathing. The changing output voltage of the thermistor varies the bias of a transistor; the transistor output signal is then applied through a calibrate card in "E" package, to two 1.3 Kc voltage controlled oscillators in "D" package. The output of the VCO's is then applied to the Hi and Lo frequency telemetry transmitters. The calibrate card provides a means of interrupting the signal for "R" and "Z" calibrate. A potentiometer in the electronic assembly provides an adjustment for sensitivity.

13-43. Astronaut Body Temperature

Body temperature is sensed by a rectal temperature probe. The probe is a 1490 $^{+10}_{-40}$ ohm thermistor element which is utilized as one leg of a bridge circuit, which forms the inputs to two d-c amplifiers. The output of each amplifier is applied to the telemetry commutators. The zero to 3 vdc output represents a temperature range of 95° to 108° C. Both amplifiers are "R" and "Z" calibrated by ground command.

13-44. Sequence System Normal Launch

Normal launch sequence instrumentation consists of monitor circuits for tower release, capsule separation, retrograde attitude command, and retrograde rocket assembly jettison. These signals are all on-off type functions and each is applied to the HF and LF Commutators.

13-45. Satellite Clock

The satellite clock utilizes potentiometers to provide electrical signals representative of elapsed time from launch and retrograde time. These potentiometers are excited with three volts from the instrumentation power supply. The outputs for each type of time are divided in signals representative of 0 to 10 seconds, 0 to 1 minute, 0 to 10 minutes, 0 to 1 hour, 0 to 10 hours and 0 to 30 hours. Wiper output is linearly proportional from zero to three volts for each time span. Wiper outputs are applied to the HF and LF Commutators. Instrumentation monitors ELAPSED TIME from LAUNCH and also EVENT TIME of retrograde. Elapsed time from launch is the length of time capsule has been in motion. Prior to lift-off, elapsed time will be zero. Instrumentation recording devices also will indicate zero time. Output signals for elapsed time therefore are directly proportional to time. As time increases so will output voltage, for example, elapsed time recorded by clock is 10 hours, 5 minutes and 10 seconds. Output signals will then be as shown below:

SATELLITE CLOCK OUTPUTS FOR 10 HOURS,
5 MINUTES, 10 SECONDS, AFTER LAUNCH

TIME POTENTIOMETERS	POTENTIOMETERS WIPER TRAVEL IN %	SIGNAL VOLTAGE
0 - 10 Hours	100%	3 Volts
0 - 1 Hour	100%	3 Volts
0 - 10 Minutes	50%	1.5 Volts
0 - 1 Minute	100%	3 Volts
0 - 10 Seconds	100%	3 Volts

Event time of retrograde is pre-set prior to lift-off. After retrograde time has been set, instrumentation will receive this time signal continuously throughout the mission. Event time of retrograde can be changed at any time during the mission by either the Astronaut or by ground command. When retrograde time is changed during the mission, instrumentation will receive this change also. Signal output voltage is proportional to retrograde time. For example, if retrograde is set to commence at 20 hours, 5 minutes and 5 seconds, instrumentation will be receiving the signal voltage outputs as shown below:

SATELLITE CLOCK OUTPUTS FOR RETRO-FIRE AT 20 HOURS,
5 MINUTES AND 5 SECONDS

TIME POTENTIOMETERS	POTENTIOMETERS WIPER TRAVEL IN %	SIGNAL VOLTAGE
0 - 10 Hours	100%	3 Volts
0 - 1 Hour	100%	3 Volts
0 - 10 Minutes	50%	1.5 Volts
0 - 1 Minute	100%	3 Volts
0 - 10 Seconds	50%	1.5 Volts

13-46. Tower Separation

When the tower separates from the capsule, the No. 3 tower separate sensor relay de-energizes and applies three volts d-c to the commutators. This signal is present for the remainder of the mission.

13-47. Capsule Separation

When the capsule separates from the booster, a limit switch closes and causes the No. 1 capsule separation sensor relay to energize. While this relay is energized a three volt d-c signal is applied to both commutators. This relay remains energized for the remainder of the mission.

13-48. Retrograde Attitude

The retrograde attitude command signal normally occurs when the retrograde clock runs out. It may also be caused by ground command or by operation of a bypass switch on the instrument panel. This signal remains present until the retrograde rocket assembly is jettisoned (approximately 90 seconds). Signal level is approximately three volts. Normally open contacts of the retrograde attitude command relay in retrograde relay box No. 2 closes to route the signal to the HF and LF Commutator.

13-49. Retrograde Rocket Assembly Jettison

The retrograde rocket fire occurs at five second intervals. The first fire occurs thirty seconds after reception of retrograde clock runout if the retrograde interlock is closed in the ASCS.

The retrograde rocket assembly jettison signal occurs 60 seconds after the initiation of the retrograde fire signal. The signal is routed through normally open contacts of the retrograde rocket assembly separation sensor relay in retrograde relay box No. 1. This relay is energized by limit switches which close when the retrograde assembly is blasted away from the capsule. The relay remains energized until the 0.05g relay drops out. (The 0.05g relay de-energizes at 10,000 feet.) A d-c signal of approximately 3 volts is applied through normally open contacts of this relay to the HF and LF Commutators.

13-50. Emergency Escape Sequence

Emergency escape sequence instrumentation consists of Mayday abort and tower escape rocket fire signal monitors.

13-51. Mayday

The Mayday signal is produced by the Mayday alarm relay. This relay is energized by any abort signal. With the relay energized, three volts d-c (nominal) is applied to the HF and LF Commutators. Once initiated, this signal is present for the remainder of the mission. The Mayday alarm relay is in launch and orbit relay box No. 4.

13-52. Astronaut's Abort Switch

Instrumentation is provided to monitor an abort signal originating from the Astronaut's Abort Handle; this signal is applied to both commutators.

13-53. Tower Escape Rocket

The tower escape rocket signal is obtained from the emergency escape rocket fire relay in launch and orbit relay box No. 2. This relay remains energized for less than one second but a capacitor is connected across the input to the HF and LF Commutators to maintain a signal level of more than 0.3 volt for approximately 30 seconds.

13-54. Landing System Sequence

Landing system instrumentation consists of monitor circuits for chute deploy and jettison and release of the antenna fairing. These signals are approximately three volts and are applied to the HF and LF Commutators. Main and reserve chute deploy signals are obtained from toggle switches in the chute compartment. Lanyards from the chutes operate these switches when the chutes deploy. The main chute jettison signal is obtained through a limit switch in the chute compartment. The antenna fairing release signal comes from the antenna fairing separation relay in the communications relay box. This relay is energized through a limit switch. All landing system signals remain on until impact.

13-55. 0.05G Relay

Instrumentation of 0.05g relay operation consists of an on-off type signal which indicates whether the relay is energized or de-energized. The relay may be energized by operation of the 0.05g sensor or by the command receiver. When the relay is energized a d-c signal is applied to the HF and LF Commutators.

13-56. Drogue Chute

Drogue chute deployment is monitored by a three volt signal controlled by the drogue chute sensor, through a set of contacts on the antenna separation relay and is applied to both commutators.

13-57. Landing Bag

The landing bag operation is monitored by a voltage signal applied to the HF and LF Commutators through two sets of unlock signal limit switches.

13-58. Periscope Retract and Door Closure

The periscope retract signal monitors the voltage applied to the retract relay. While the periscope is retracting, 24 volts d-c is applied through an attenuator in package "C" to both commutators. Input level to the commutators is approximately three volts.

13-59. INSTRUMENTATION CONTROL SYSTEM

13-60. Coding

The signals applied to the HF and LF Commutators are sampled once every 0.80 seconds. Commutator outputs are square wave pulses with amplitude between -1 and +3 volts. These pulses are applied to voltage controlled oscillators and pulse duration modulation converters.

a. The frequencies of the voltage controlled oscillators are varied between 10.5 Kc $\pm$ 6-3/4% by the commutated pulse amplitude signals. This frequency band corresponds to IRIG Channel 12. The frequency modulated outputs of the 10.5 Kc voltage controlled oscillators are applied to two mixers.

b. Commutator pulse amplitude modulation signals are also applied to pulse duration modulation converters. The converters reshape the pulse amplitude wave-shapes to obtain pulse duration wave trains. These wave trains are then applied to the tape recorder.

c. Amplified aeromedical signals are coupled to pairs of 1.3 Kc, 1.7 Kc and 2.3 Kc voltage controlled oscillators. A zero to full scale signal causes a deviation in center frequency of $\pm$ 6-3/4%. The frequency bands of the oscillators correspond to IRIG Channels 5, 6 and 7. The oscillator outputs are applied to mixers.

d. In the mixers, the commutated outputs and the aeromedical signals are combined. Mixer A also accepts a signal from the compensating oscillator. (This signal serves as a reference during data evaluation to indicate fluctuations in tape speed.) The composite signal from each mixer is applied to the tape recorder, the ground test umbilical and a telemetry transmitter.

13-61. Transmission

Ground testing and control of the instrumentation system is provided through the umbilical receptacle. Non-radiating checks can be performed to evaluate system operation. Radiating checks are performed through the telemetry link. Refer to Section XI for further information regarding telemetry.

13-62. Instrumentation Control

The instrumentation system controls and programs (see Table 13-1) power to its own and other systems equipment by means of mode relays and programmer. (See Figure 13-3.)

a. The ASCS horizon scanners are powered at regular intervals during the mission to provide reference signals for the capsule gyros.

b. The water extractor in the environmental control system is also programmed at regular intervals during the mission.

c. The pilot and instrument panel observer camera operates at a high and low rate of speed during various phases of the mission.

d. Calibration voltages, R-calibrate for maximum readings and Z-calibrate for minimum readings, are supplied periodically to the monitoring instrumentation circuits. This is done prior to launch and by ground command at intervals during orbit.

e. The X and Y axes accelerometer ranges are $\pm$ 4 g from launch until orbit and from retro command until landing. These ranges are changed to $\pm$ 0.5g while the capsule is in orbit. The Z axis accelerometer range is $\pm$ 30g throughout the mission.

13-63. INSTRUMENTATION RECORDING (See Figure 13-3).

Recording instrumentation consists of a tape recorder and two cameras.

TABLE 13-1. INSTRUMENTATION PROGRAMMING

CAMERA	Before Umb. Separation	Umb.Ej.to Cap Sep + 60 Sec.	Cap. Sep. Plus 60 Sec.to Tr.	Tr.to Retro Jettison	Retro Jett. to .05G	.05G to Ht.Shld. Deploy	Ht.Shld. onward	MayDay onward
ASTRONAUT-PRIMATE 9-13-16-18-19	1 frame/ 12 Sec.	6 frames/ Sec.	1 frame/12 Sec.,Except 6 frames/ Sec. every 30 Min.	6 frames per Sec.	1 frame per 12 Sec.	6 frames per Sec.	1 frame per 12 Sec.	6 frames per Sec.
INSTRUMENT PANEL OBSERVER CAMERA 9, 13, 16,18,19	Slow 1F/2 Sec.	Fast 6 FPS	Slow,Except fast 30 Sec. every 30 Min	Fast	Slow	Fast	Slow	Fast
PERISCOPE CAMERA 8, 9			1800 frames* per hour					
EARTH AND SKY OBSERVER CAMERA CAPSULE 8, 9		10 frames per Min.	10 frames per Min.	10 frames per Min.	10 frames per Min.	10 frames per Min.	10 frames per Min.	
HORIZON SCANNER	Operating	Operating	8.5 Min/ 30 Min.		OFF at Re-entry			
ECS WATER EXTRACTOR 8,9,13, 16,18,19								30 Sec/ 30 Min.
PLAYBACK TAPE RECORDER 8-9		On until tape depletion at 35 Sec./180 Sec. with 90 Min. stagger.						
INST. PANEL OBSERVER CAMERA	6 FPS	6 FPS	1800 FPH	6 FPS	6 FPS	6 FPS	6 FPS	

13-64. Tape Recorder

A low power, lightweight tape recorder provides seven channels for data recording. Mixer A output, voice communications, LF Commutator, pulse duration modulation and HF Commutator pulse duration modulation signals are applied to channels 1, 2, 3, 4, 5 and 7, respectively. The tape recorder operates continuously during ascent and descent, and is on 1 minute and off 3 minutes during orbit. In addition, the recorder is turned on during any voice transmission from the capsule. Recorder speed is 1-7/8 inches per second.

13-65. Instrument Panel Camera

A 16 millimeter camera is installed in the capsule to observe the main instrument panel. This camera is mounted to the left of the Astronaut's head and views the panel from over his shoulder. The camera is supplied 24 volts d-c from the capsule power system. Operation of the camera is controlled by also applying 24 volt d-c power pulses to the camera clutch. Each pulse trips the shutter, exposing one frame, and advances the film for the next exposure. The camera operates at a high speed of 6 frames per second and a low speed of one frame every two seconds. The Instrument Panel Observer Camera contains 450 feet of 16 millimeter film. Power is applied through an Instrumentation Mode relay and programmer and internal camera programmers which produce the necessary power pulses; these are supplied during ascent, descent and orbit at speeds shown on Table 13-1.

13-66. Astronaut Camera

A 16 millimeter camera mounted behind the lower left corner of the main instrument panel views the Astronaut. This camera is also supplied 24 volt d-c power and trigger pulse voltage. The Astronaut camera operates at a high speed of 6 frames per second and a low speed of 1 frame every 12 seconds. The camera normally contains 250 feet of 16 millimeter film. Internal clock, time

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

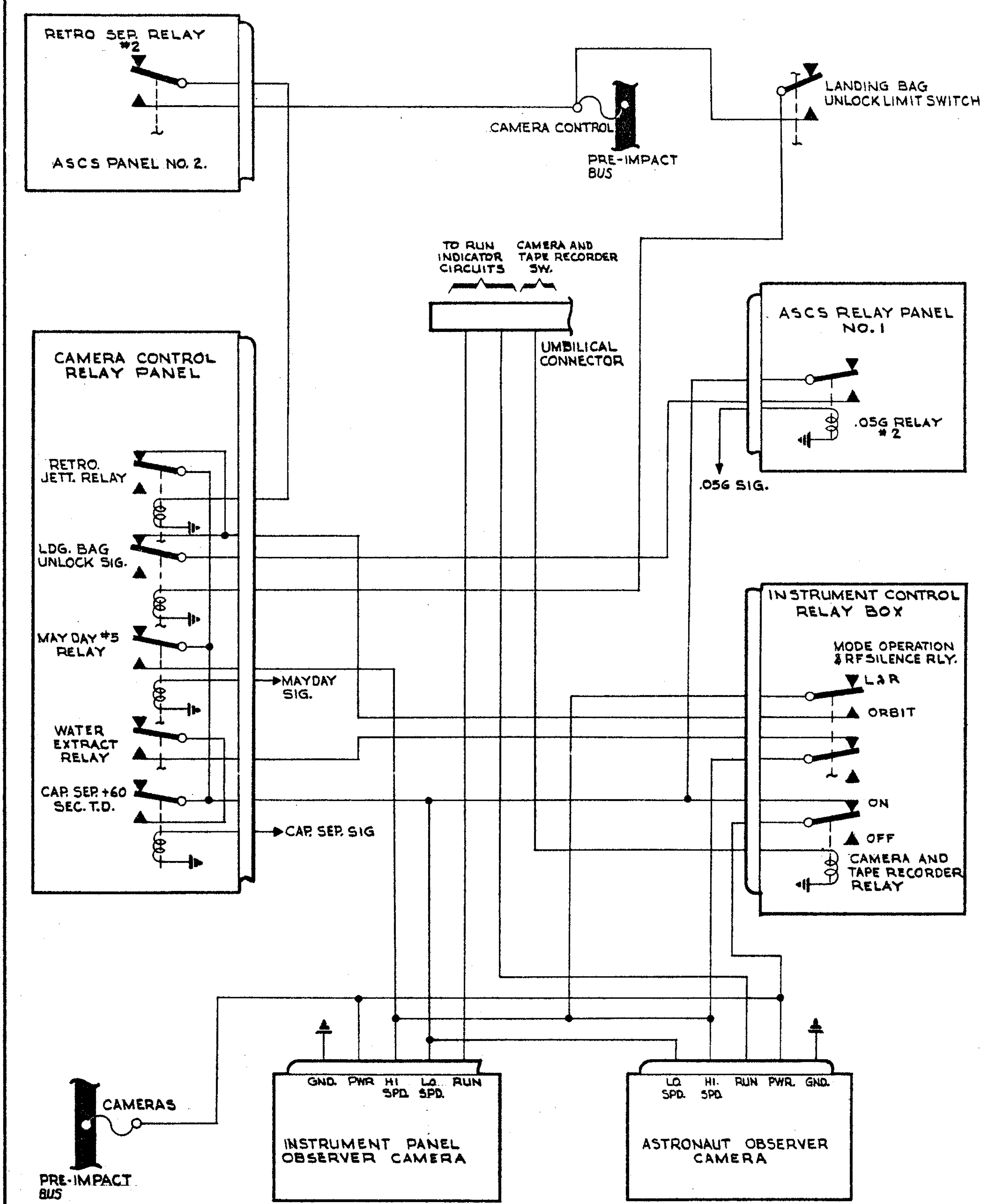


FIGURE 13-3 CAMERAS AND TAPE RECORDER CONTROL CIRCUIT (CAPSULES 10,13,16,18,19)

PM45-117E

correlation is included within the camera. Operation is similar to that of the instrument panel observer camera. Camera speeds are supplied at varying rates as shown on Table 13-1. The cameras and tape recorder can be controlled through the umbilical during ground checkout. Return circuits from these components to the umbilical provide indications of component operation.

13-67. SPECIAL INSTRUMENTATION

Not applicable to a manned capsule.

13-68. SYSTEM UNITS

13-69. TRANSDUCERS

Potentiometer type transducers are connected across instrumentation 3 volt d-c power. The wiper is activated by the action to be measured. Wiper voltage is then proportional to the action.

13-70. Control Stick Motion Potentiometers

Control stick motion is translated into rotary potentiometer movement. One potentiometer is provided for each axis of motion.

13-71. Satellite Clock Potentiometers

The satellite clock (refer to Section XII) utilized potentiometers to indicate elapsed time from launch and time to retrograde outputs for 0-10 seconds, 0-1 minute, 0-10 minutes, 0-1 hour, and 0-10 hours.

13-72. Manual and Automatic Supply Helium Pressure Potentiometers

Helium supply pressure, 2250 psig maximum, actuates the wiper of each potentiometer transducer to a resistance position proportional to the pressure.

13-73. Attitude Potentiometers

The ASCS calibrator (refer to Section IV) provides synchro actuation of potentiometers for pitch, roll and yaw. Each wiper output is then proportional to the capsule attitude for that axis.

13-74. Main and Reserve Oxygen Pressure Potentiometers

Each oxygen bottle pressure actuates a dual potentiometer transducer. A low resistance linear element is used to operate a panel indicator while a higher resistance linear element is used for instrumentation. Wiper voltage outputs are proportional to applied oxygen pressure.

13-75. Static Pressure, Suit Pressure and Coolant Quantity Pressure Potentiometers

Each pressure transducer is used to provide a linear output proportional to the applied pressure. Pressure ranges are 0-15 psia for static pressure, 0-15 psia for suit pressure and 0-500 psia for coolant quantity pressure.

13-76. Respiration Rate and Depth Thermistor

Pilot breathing actuates a thermistor mounted in the helmet microphone area. Respiration depth is determined by the extremes to which the thermistor is actuated while breathing rate determines the frequency of actuation.

13-77. Resistance Element Transducers

Resistance elements are used to measure temperatures. The resistance of the element varies proportionally to its temperature. Mounting of the element depends on the application. Stick-on surface temperature elements are small, lightweight units. Other elements are mounted as an integral part of the capsule structure. The following list indicates the purpose and approximate temperature and resistance ranges for each transducer.

(a) Outer Skin Temperature: -65° to 2200°F

(b) Ablation Temperature: -55° to 1000°F

(c) Suit Inlet Temperature: 35° to 100°F - 249 to 300 ohms

(d) Cabin Air Temperature: 0° to 200°F - 216 to 316 ohms.

13-78. Body Temperature Transducer

The body temperature transducer is a rectal temperature pickup which consists of a thermistor imbedded in sealing compound at the end of a flexible pigtail.

13-79. D-C Current Shunt

The shunt resistance used for the instrument panel ammeter also supplies voltage for instrumentation. This shunt is discussed in Section XI of this manual.

13-80. Electrocardiograph Pickups

Cardiac activity is sensed by four, one half inch square, stainless steel wire screens. These electrodes are attached with silver metalized adhesive to the Astronaut's body. Small connecting wires leading to the Astronaut's suit disconnect, complete the circuit.

13-81. Oxygen Partial Pressure Transducer

The O_2 Partial Pressure transducers are used to convert O_2 partial pressures to a signal compatible with high level telemetry. The voltage range of 0-3 V d-c output is representative of 0-6 psi oxygen partial pressure.

13-82. TAPE RECORDER

A low power, lightweight tape recorder is used in the capsule to make available 7 channels of recorded data. At the present time channel assignments are as follows: Channel 1, HF VCO mixer output; Channel 3, voice communications; Channel 5, LF Commutator PDM; Channel 7, HF Commutator PDM. Tape speed is 1-7/8 ips, convertible to 15 ips by a modification kit. Tape capacity is 4800 feet of ½ inch wide mylar base tape. The tape transport consists of a capstan drive, supply reel and take-up reel mechanism. A d-c motor is used, through reduction gearing, for capstan drive. A limit switch is provided to interrupt recorder power should the tape break. Record amplifiers are incorporated in the unit for Channels 1 and 3. Channels 5 and 7 utilize amplifiers incorporated in the commutators located in instrumentation package "A".

13-83. INSTRUMENTATION PACKAGE "C"

The "C" package incorporates units of various functions into one compact panel allowing convenience of mounting and of making electrical connections. These various sub-units are discussed in the following paragraphs.

13-84. Cabin Pressure Transducer

Cabin pressure actuates the wiper of a 10,000 ohm potentiometer located in the "C" package. Three volts d-c from the "A" package is applied across the potentiometer. Wiper output voltage is then proportional to the cabin pressure.

13-85. Topic Cards

The instrumentation package utilizes a unique method of construction and mounting of the transistorized amplifiers, power suppliers, attenuators and monitors. Each unit consists of the necessary component parts mounted on a printed circuit, dielectric card with printed connector contacts at the bottom for plug-in insertion. The card is then covered, with the exception of base connector contacts and side mounting edges, with a thin layer of epoxy resin. This coating is used to provide moisture protection, to insure operation in a 100% oxygen atmosphere and to improve mechanical rigidity of components. These "Topic Cards" are package mounted in boxes providing side rails, base contact receptacles and printed circuit inter-connections.

13-86. D-C Current Amplifier Cards

Two amplifiers are used to bring the d-c current shunt voltage up to a maximum of 3 volts d-c. One amplifier is used for the HF Commutator while the other is used for the LF Commutator. The amplifiers are transistorized and card mounted.

13-87. Respiration Rate and Depth Calibration and Attenuator Card

Relays mounted on this card allow "R" and "Z" calibration of the signal supplied from the respiration rate and depth transducer. One relay is supplied for "R" calibration and one for "Z" calibration. Energizing the desired relay breaks the normal circuit and applies the calibration voltage to the commutators. Resistors are also mounted on the card for attenuation of 24 volt d-c voltages to proportional voltages compatible with the commutators.

13-88. Voltage Monitor Cards

Resistors, capacitors and circuit isolating crystal diodes are used to attenuate reaction control solenoid valve energizing voltages, standby battery voltage and periscope retract voltage prior to application to the commutators. Each attenuator circuit output, a maximum of 3 volts d-c, is applied to both commutators.

13-89. Horizon Scanner Card

The horizon scanner amplifier card provides circuitry for processing the scanner roll and pitch signals, roll and pitch ignore signals and "Z" calibrate prior to being applied to HF and LF Commutators. During launch and orbit the scanners are operating continuously; however, during orbit the signals applied to the ASCS and the commutators are timed by the programmer located in "C" package. In addition, the horizon scanner slaving signal is applied to the HF commutator.

13-90. PROGRAMMER

The programmer contains switch contacts which operate control circuits for specific intervals. The programmer is mounted on the forward side of the periscope housing.

13-91. A - Section

The programmer used for orbital missions consists of two sections. When power is applied to the programmer, electronic controlled timers continuously operate the following contacts:

CONTACTS CLOSED

WAFER SECTION	DURATION	RATE
1. Water Extraction	30 Seconds	1 per 30 minutes
2. Full Scale Calibrate	5 Seconds	See Table 13-2
3. Zero Calib.	5 Seconds	See Table 13-2

13-92. B - Section

The B Section of the programmer is energized through the command receiver-decoders and the electronic timers to provide full scale and zero calibrate signal, as follows:

CONTACTS CLOSED

WAFER SECTION	DURATION	RATE
1. Full Scale Calibrate	3 Seconds	On Command
2. Zero Calibrate	3 Seconds	On Command

13-93. INSTRUMENTATION PACKAGE "A"

The "A" package also incorporates units of various functions into one panel. These sub-units are discussed in the following paragraphs.

13-94. Cabin Air Temperature Transducers

A platinum resistance wire is used to measure cabin air temperature. Temperature changes from 0^{o} to $200^{o}F$ cause the element to change resistance from 200 to 300 ohms. The resistance element forms a part of an amplifier circuit. Two transducers are used in conjunction with two amplifiers to supply signal to both commutators.

13-95. Filament Transformer

A filament transformer is used to step down 115 volts 400 cps capsule power to 6.3 volts for use in packages "A" and "C".

13-96. Topic Cards

The instrumentation package "A" also utilizes the Topic Card principle for amplifiers and power supplies.

13-97. Resistance Element Amplifier Cards

The same type amplifier is used for heat shield outer skin, suit inlet air and cabin air temperature transducer signals. Each amplifier is of dual channel design in order to accommodate the two transducers used to measure each type of temperature. Seven volts, 400 cps is supplied from the resistance element power supply. This voltage is applied across a bridge circuit in each amplifier. The transducer associated with each bridge circuit causes the voltage in the circuit to vary proportionally to the transducer temperature. This voltage change appears across a transformer and is rectified, using crystal diodes, to a maximum output of 3 volts d-c. The two outputs from each amplifier are supplied to the commutators. Two relays on each card amplifier allow full scale and zero calibration of each channel. Calibration potentiometers are also provided for each channel.

13-98. Resistance Element A-C Power Supply Card

Resistance element amplifier circuits require 7 volts, 400 cps a-c. Capsule power, 24 volts d-c, is applied to a transistorized power inverter. The inverter, using zener diode-transistor voltage regulation and transistor switching, supplies a 7 volt a-c output which is monitored by an attenuator, rectifier circuit. The monitor output, a maximum 3 volts d-c, is applied to the commutators.

13-99. Body Temperature Amplifier Cards

Two transistorized d-c amplifiers are used to increase the output of the temperature transducer to a maximum 3 volt d-c level prior to application to the commutators. These amplifiers are of the same type as those used in instrumentation package "C" for d-c current amplification.

13-100. Signal Condition and D-C Supply Card

This Topic Card provides four functions in the instrumentation system. Filament transformer output is applied to a monitor circuit. This circuit attenuates and rectifies to provide a maximum 3 volt d-c signal indicating transformer operation. Capsule power, 24 volts d-c, is applied to an attenuator circuit which provides a 3 volt d-c output for the monitoring circuit. This 3 volt output is then applied to the commutators as a monitor of the main 24 volt d-c bus voltage. The signal condition and d-c power supply card also provides meter attenuator resistors which limit current flow in the panel indicator circuits. These circuits involve the main and reserve oxygen supply pressures, the automatic and manual fuel supply pressures and the coolant quantity circuit.

13-101. HF and LF Commutator-Keyer-Record Amplifiers

Two units are provided in the "A" package for commutating transducer data and supplying PDM and PAM outputs. The commutator portion of each unit is a 90 x 1¼, solid state device which samples sequentially, 88 channels of signal input information. The output produced is a pulse amplitude modulated signal wave train. Each 0 to 3 volts d-c input to the commutator is sampled 1¼ times per second per IRIG standards. The PAM wave train output is fed through a buffer stage to a PAM/PDM converter. The PDM output is then applied to a record amplifier which produces a signal capable of directly driving the recorder head in the capsule tape recorder. The PAM output is fed through a gating circuit which introduces a master pulse and negative pedestal pulses to operate automatic decommutation equipment in the ground station. A power supply is incorporated in the unit to provide the positive and negative voltages required in the circuits.

13-102. INSTRUMENTATION PACKAGE "D"

The primary function of the "D" package is to convert capsule information to signals capable of modulating the telemetry transmitters. Transducers and amplifiers are also contained in the package to complete capsule information circuits.

13-103. Accelerometers

Three accelerometers are mounted in the "D" package and used to determine the static longitudinal, lateral and normal accelerations of the capsule. Each unit gives a d-c output which is applied to 3 channels of each commutator.

13-104. Electrocardiogram Amplifier Cards

Four amplifiers are used for the EKG transducer inputs. Each amplifier increases the transducer output to a 3 volt peak to peak signal.

13-105. Oscillators

The "D" package supplies sub-carrier oscillators to allow two channels of instrumentation data. The A channel is associated with the HF commutator, high frequency telemetry transmitter and tape recorder. The B channel is associated with the low frequency telemetry transmitter. The following paragraphs describe the sub-carrier oscillators.

13-106. Compensating Oscillator Card

During playback of a tape, the recorded signal from this oscillator is monitored to detect changes in tape recorder speed. A frequency shift indicates a change in speed. The oscillator is of Topic Card construction and operates at 3125 cps. Output level is adjustable.

13-107. Voltage Controlled Oscillator (V.C.O.) Cards

Instrumentation data voltages are applied to the sub-carrier oscillators causing oscillator frequency shift proportional to the input amplitude. The transistorized oscillator consists of a free running multivibrator and filter. The oscillator functions and frequencies are given below:

(1) Channel A

Commutator - 10.5 kc

Right side (+) Ekg V.C.O. 2.3 Kc

Left side (Comm) Ekg V.C.O. 2.3 Kc

Lower Chest (+) Ekg. V.C.O. 1.7 Kc

Upper Chest (Comm) Ekg. V.C.O. 1.7 Kc

Respiration rate and depth - V.C.O. 1.3 Kc

Compensating oscillator - 3.125 Kc

(2) Channel B

Commutator - 10.5 Kc

Right Side (+) Ekg V.C.O. 2.3 Kc

Left Side (Comm) Ekg V.C.O. 2.3 Kc

Lower Chest (+) Ekg V.C.O. 1.7 Kc

Upper Chest (Comm) Ekg V.C.O. 1.7 Kc

Respiration rate and depth - V.C.O. 1.3 Kc

13-108. Mixer Amplifier Card Power Supply

Capsule power, 24 volts d-c, is converted to 6 volt d-c for use by the sub-carrier oscillators. A mixer circuit combines the sub-carrier oscillator outputs. Solid state components for these circuits are combined on one Topic Card.

13-109. CAMERAS

13-110. Instrument Panel Observer Camera

A standard camera is modified by the application of a special drive motor, self contained slow and fast programmer and a special housing. Slow operating of the motor shutter mechanism and film transport begins when the capsule camera and tape record relay is de-energized by the block-house. Full capacity is 450 feet of 16 millimeter film.

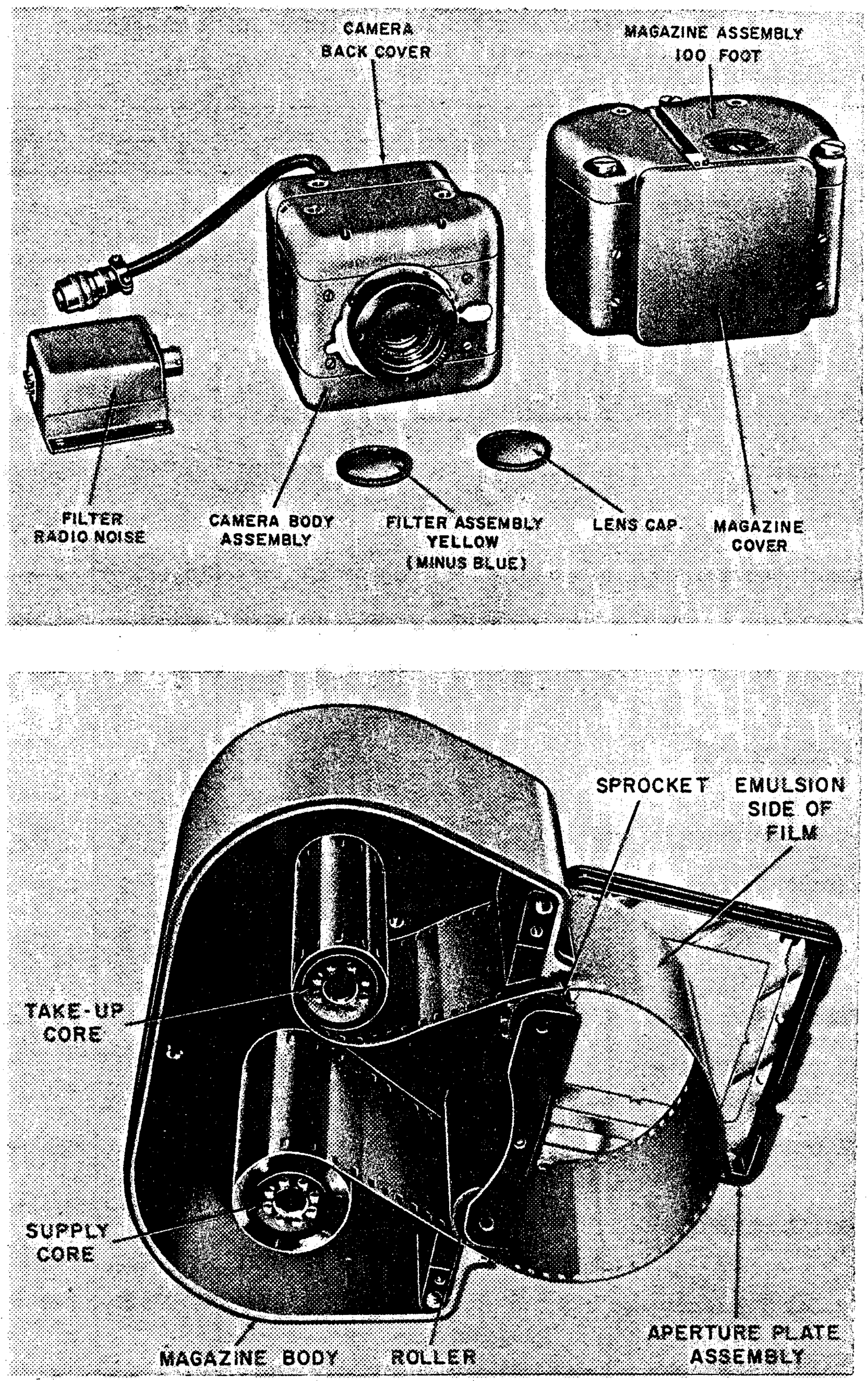


FIGURE 13-4 EARTH AND SKY OBSERVER CAMERA

PM45-198A

Table 13-2. Instrumentation Commutator Point Assignment (High Level 0-3 Volt.)

	8		9		10		13		16	
	HF	LF	HF	LF	HF	LF	HF	LF	HF	LF
ELECTRICAL POWER SYSTEM										
18V Isol Bus	12	12		59	------		------		------	
18V Stby Bus	12	12		59	------		------		------	
Fans A-C Bus	41	41	41	41	41	41	33	33	41	41
ASCS A-C Bus	------		------		------		77	77	------	
D-C Current	42	42	42	42	42	42	42	42	42	42
Standby Inverter ON	62	62	62	62	62	62	62	62	62	62
Standby Batteries ON	63	63	63	63	63	63	63	63	------	
ASCS Sloving	------		------		63	63	63		63	63
24 Volts D-C	83	83	83	83	83	83	26	26	83	83
INSTRUMENTATION POWER SUPPLIES										
3V D-C Reference	1	1	1	1	1	1	1	1	1	1
0V (Zero) Reference	2	2	2	2	2	2	2	2	2	2
7V, 400 CPS	3	3	3	3	3	3	3	3	3	3
STATIC PRESSURE	22	22	22	22	22	22	22	22	22	22
VIBRATION (COMMUTATOR A ONLY)	5 49	27 71								
CALIBRATION ON	64	64	64	64	64	64	64	64	64	64
ENVIRONMENTAL CONTROL SYSTEM										
Suit Inlet Pressure	8	8	8	8	8	8	8	8	8	8
Main O_2 Supply Pressure	9	9	9	9	9	9	9	9	9	9

Table 13-2. Instrumentation Commutator Point Assignment (High Level 0-3 Volt.) (Cont'd.)

	8		9		10		13		16	
	HF	LF	HF	LF	HF	LF	HF	LF	HF	LF
ENVIRONMENTAL CONTROL SYSTEM (Cont'd.)										
Cabin Temp.	10	10	10	10	10	10	10	10	10	10
Suit Inlet Air Temp. (Aft)	11	11	11	11	11	11	11	11	11	11
Reserve O_2 Supply Pressure	------		12	12	12	12	12	12	12	12
Cabin Pressure	82	82	82	82	82	82	82	82	82	82
Coolant Quantity	84	84	84	84	84	84	84	84	84	84
Suit O_2 Partial Pressure	6	6	6	6	6	6	------		6	6
REACTION CONTROL SYSTEM										
Reaction Cont. Supply Pressure (Auto.)	39	39	39	39	39	39	39	39	39	39
Reaction Cont. Supply Pressure (Man.)	40	40	40	40	40	40	40	40	40	40
Hand Control Positions										
Roll	------		------		23	23	------		23	23
Pitch	------		------		24	24	------		24	24
Yaw	------		------		25	25	------		25	25
ACCELERATION										
Y Axis	13 43 73	43 13 73	13 43 73	43 13 73	13 43 73	43 13 73	13 43 73	43 13 73	14 44 74	14 44 74
X Axis	14 44 74	44 74 14	14 44 74	44 74 14	14 44 74	44 74 14	14 44 74	44 74 14	15 45 75	15 45 75
Z Axis	15	45	15	45	15	45	15	45	15	15

Table 13-2. Instrumentation Commutator Point Assignment (High Level 0-3 Volt.) (Cont'd.)

	8		9		10		13		16	
	HF	LF	HF	LF	HF	LF	HF	LF	HF	LF
ACCELERATION										
Z Axis (Cont'd.)	45 75	75 15	45 75	75 15	45 75	75 15	45 75	75 15	45 75	45 75
STRUCTURAL TEMPERATURE										
Heat Sink	19	19	------		------		19	19	------	
Ablation Shield Temp.	------		19	19	19	19	------		------	
Outer Skin Temp.	20	20	20	20	20	20	20	20	20	20
Inner Skin Temp.	21	21	------		21	21	21	21	------	
250VA Inverter Temp.	------		21	21	------		------		21	21
150VA Inverter Temp.	------			21	------		------		------	
AEROMEDICAL DATA										
EKG	------		* 1.7 & 2.3 Kc VCO's		* 1.7 & 2.3 Kc VCO's		* 1.7 & 2.3 Kc VCO's		* 1.7 & 2.3 Kc VCO's	
Respiration	------		* 1.3 Kc VCO's		* 1.3 Kc VCO's		* 1.3 Kc VCO's		* 1.3 Kc VCO's	
Body Temperature			4	4	4	4	4	4	4	4
0.05G RELAY	87	87	87	87	87	87	87	87	87	87
HORIZON SCANNER										
Pitch Output	86	86	40		86		------		88	
Roll Output	88	88	88	88	88		------		86	
Pitch Ignore	25	25	85		85		------		85	

Table 13-2. Instrumentation Commutator Point Assignment (High Level 0-3 Volt.) (Cont'd.)

	8		9		10		13		16	
	HF	LF	HF	LF	HF	LF	HF	LF	HF	LF
HORRIZON SCANNER (Cont'd)										
Roll Ignore	59	59	85		85		------		85	
ATTITUDE										
Pitch	16	86	16 %	16	16	16	16	86	16 %	16
Roll	17 88	88 17	17	17	17	17			17 %	17
Yaw	18	18	18 %	18	18 %	18	18	18	18 %	18
ALTITUDE RATE										
Pitch AB	* 2.3 Kc VCO's		S 16	16	S 16	85	------		S 16	16 85
Roll AB	* 1.7 Kc VCO's		S 17	17	S 17	86	------		17	17 86
Yaw AB	* 1.3 Kc VCO's		S 18	18	S 18	88	------		S 18	18 88
RCS CONTROL SOLENOIDS										
Pitch High Up	65	65	65	65	65	65	65	65	65	65
Pitch High Down	66	66	66	66	66	66	66	66	66	66
Pitch Low Up	67	67	67	67	67	67	67	67	67	67
Pitch Low Down	68	68	68	68	68	68	68	68	68	68
Roll High CW	69	69	69	69	69	69	69	69	69	69
Roll High CCW	70	70	70	70	70	70	70	70	70	70
Roll Low CW	76	76	76	76	76	76	76	76	76	76

Table 13-2. Instrumentation Commutator Point Assignment (High Level 0-3 Volt.) (Cont'd).

	8		9		10		13		16	
	HF	LF	HF	LF	HF	LF	HF	LF	HF	LF
RCS CONTROL SOLENOIDS (Cont'd.)										
Roll Low CCW	77	77	77	77	77	77	77	77	77	77
Yaw High Left	78	78	78	78	78	78	78	78	78	78
Yaw High Right										
Yaw Low Left	80	80	80	80	80	80	80	80	80	80
Yaw Low Right	81	81	81	81	81	81	81	81	81	81
SATELLITE CLOCK (Elapsed Time)										
10 Seconds	26	26	26	26	26	26	------		26	26
1 Minute	28	28	28	28	28	28	------		28	28
10 Minutes	29	29	29	29	29	29	------		29	29
1 Hour	30	30	30	30	30	30	------		30	30
10 Hours	31	31	31	31	31	31	------		31	31
0 - 10 Seconds	32	32	32	32	32	32	------		32	32
SATELLITE CLOCK (Retrograde Time)										
10 Seconds	33	33	33	33	33	33	------		33	33
1 Minute	34	34	34	34	34	34	------		34	34
10 Minutes	35	35	35	35	35	35	------		35	35
1 Hour	36	36	36	36	36	36	------		36	36
10 Hours	37	37	37	37	37	37	------		37	37
0 - 10 Seconds	38	38	38	38	38	38	------		38	38

Table 13-2. Instrumentation Commutator Point Assignment (High Level 0-3 Volt.) (Cont'd.)

	8		9		10		13		16	
	HF	LF	HF	LF	HF	LF	HF	LF	HF	LF
INTERIM CLOCK										
0 - 10 Seconds	------		------		------		26 31 33	31 33 26	------	
0 - 100 Seconds	------		------		------		28 32 34	32 34 28	------	
0 - 1000 Seconds	------		------		------		29 37 35	37 35 29	------	
0 - 10,000 Seconds	------		------		------		30 38	38 30	------	
T R TIMER	------		------		------		36	36	------	
NORMAL LAUNCH SEQUENCE										
Sync Pulse							89	89		
Sync Pulse							90	90		
Tower Release	46	46	46	46	46	46	46	46	46	46
Capsule Separation	47	47	47	47	47	47	47	47	47	47
Retro Attitude Comd.	48	48	48	48	48	48	48	48	48	48
Retro Rkt.Assy.Jett.	53	53	53	53	53	53	53	53	53	53
Retro Rkt. No. 1 Fire	50	50	50	50	------		50	50		
Retro Rkt.No. 2 Fire	51	51	51	51	------		51	51		
Retro Rkt.No.3 Fire	52	52	52	52	------		52	52		
Retro Rkt.Assy.Jett.	53	53	53	53	53	53	53	53		
EMERGENCY ESCAPE SEQUENCE										
Pilot Abort	------		------		59	59	59	59	59	59

Table 13-2. Instrumentation Commutator Point Assignment (High Level 0-3 Volt.) (Cont'd.)

	8		9		10		13		16	
	HF	LF	HF	LF	HF	LF	HF	LF	HF	LF
EMERGENCY ESCAPE SEQUENCE (Cont'd.)										
May Day	60	60	60	60	60	60	60	60	60	60
Tower Escape Rocket	61	61	61	61	61	61	61	61	61	61
LANDING SYSTEM SEQUENCE										
Drogue Chute Deploy.	54	54	54	54	54	54	54	54	54	54
Antenna Release	55	55	55	55	55	55	55	55	55	55
Main Chute Deploy	56	56	56	56	56	56	56	56	56	56
Main Chute Jettison	57	57	57	57	57	57	57	57	57	57
Reserve Chute Deploy	58	58	58	58	58	58	58	58	58	58
Landing Bag	---	---	---	---	---	---	---	---	51	51
PERISCOPE RETRACT	72	72	72	72	72	72	72	72	72	72
INTEGRATING ACCELEROMETER	---	---	---	---	52	52	---	---	---	---
T/M VELOCITY SENSOR	---	---	---	---	50	50	---	---	---	---
PRIMATE REACTION TOTAL ANIMAL RESPONSE										
R. H. Switch	---	---	23	---	---	---	---	---	---	---
Center Switch	---	---	86	---	---	---	---	---	---	---
L. H. Switch	---	---	59	---	---	---	---	---	---	---
Pos. Identification	---	---	24	---	---	---	---	---	---	---
COMMAND RECEIVER ALL CHANNEL SIG.	4	4	---	---	---	---	5	5	---	---
PARACHUTE COMPT. PRESS	23	23	---	25	---	---	---	---	---	---

Table 13-2. Instrumentation Commutator Point Assignment (High Level 0-3 Volt.) (Cont'd.)

	8		9		10		13		16	
	HF	LF	HF	LF	HF	LF	HF	LF	HF	LF
ROLL TO YAW COM'D (Hi Gain)	------		27	27	------		------		------	
ROLL TO YAW COM'D (Lo Gain)	------		49	49	------		------		------	
YAW TORQUER SIG.	------		71	71	------		------		------	
HEAT SHIELD CAVITY PRESS.	24	24	25							
TELEMETRY INTERROGATION MONITOR	85	85								

*. Not Commutated

%. With 0.05G Relay De-Energized

S. With 0.05G Relay Energized and Retrograde Assembly Jettisoned

HF. High Frequency T/M Transmitter Commutator

LF. Low Frequency T/M Transmitter Commutator

CONFIDENTIAL

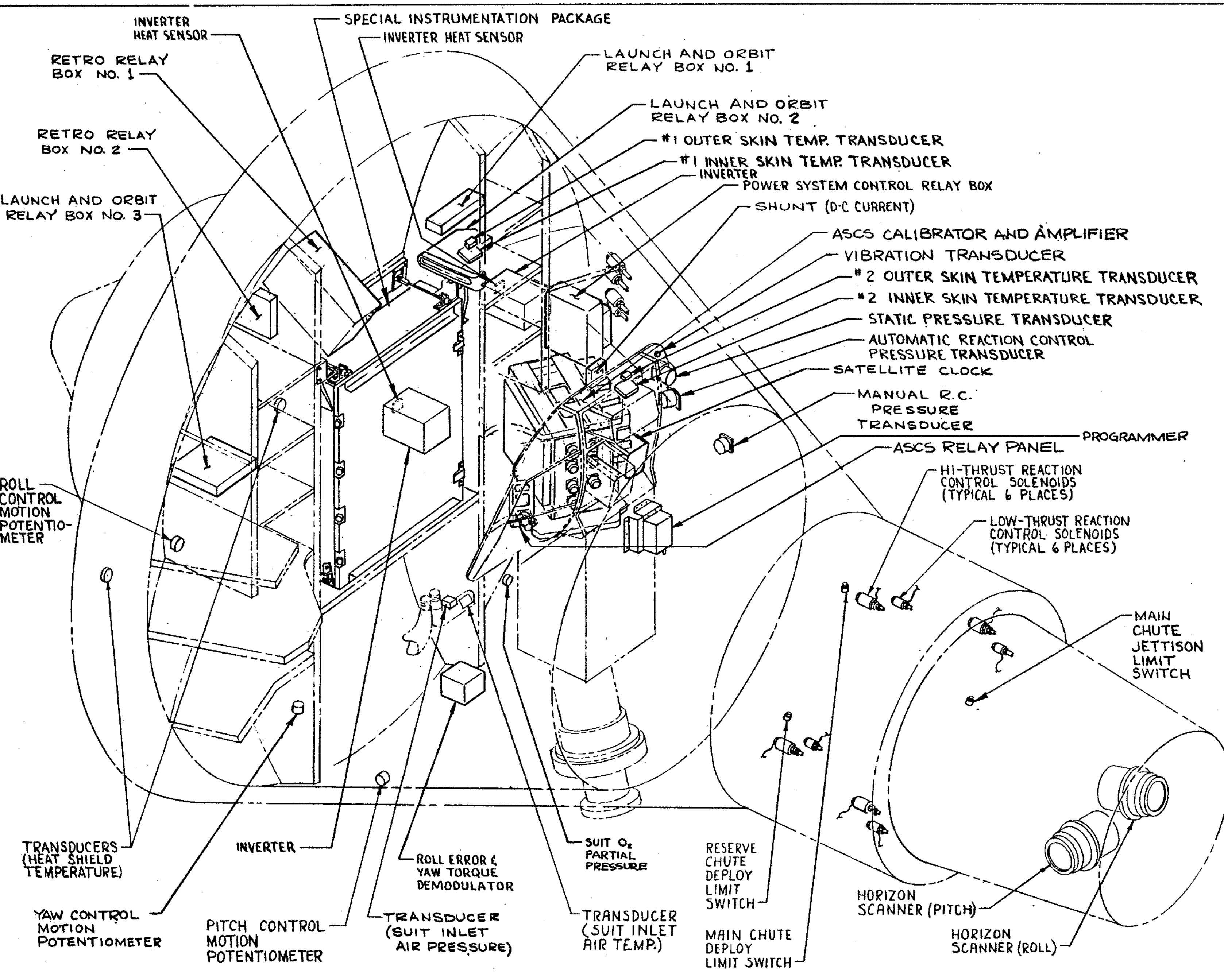


FIGURE 13-5 INSTRUMENTATION SYSTEM CAPSULE 8 (SHEET 1 OF 2)

PM45-20(G)

CONFIDENTIAL

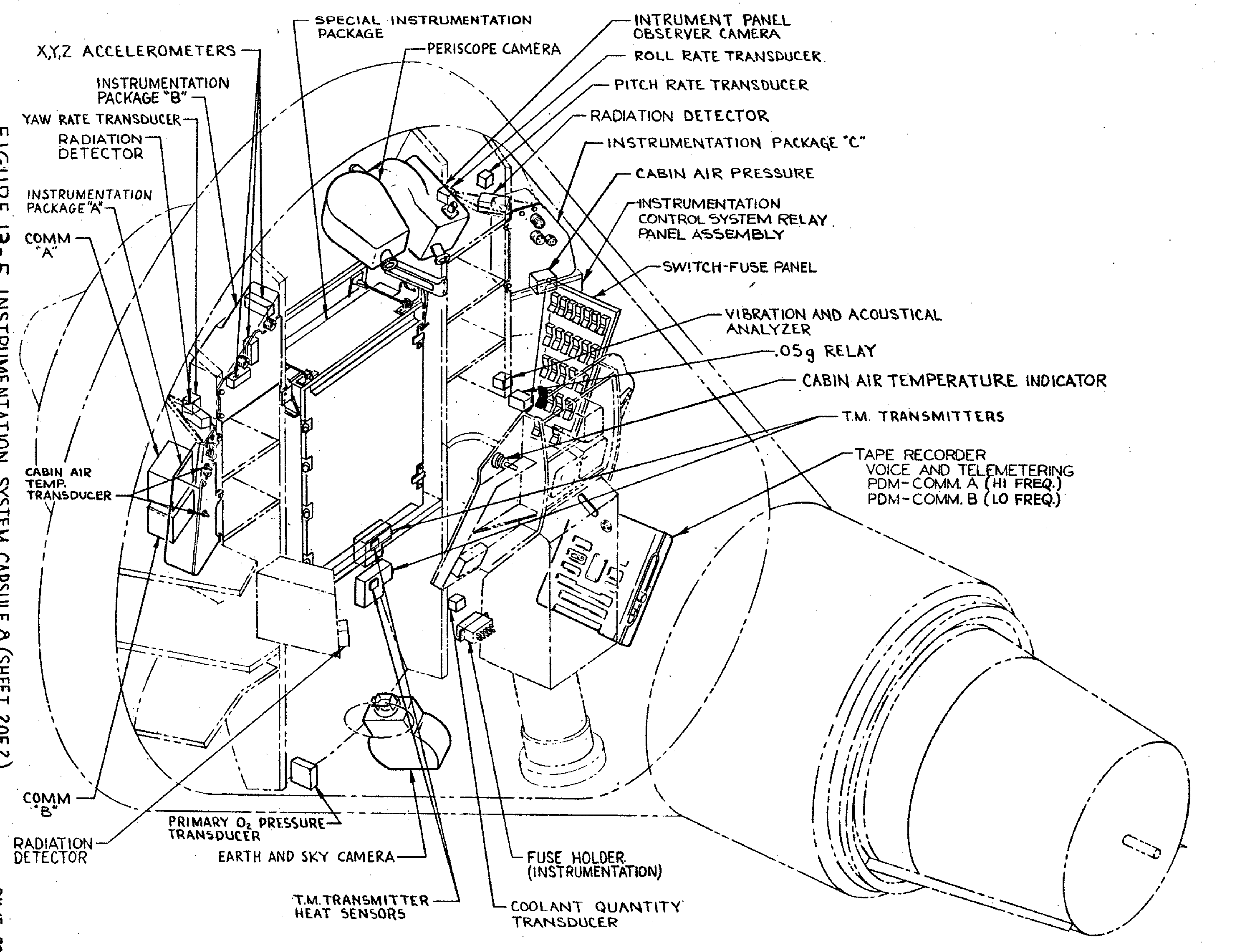


FIGURE 13-5 INSTRUMENTATION SYSTEM CAPSULE 8 (SHEET 2 OF 2)

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

CONFIDENTIAL

Table 13-3. Special Instrumentation Parameters Commutator Point Assignments (Low Level - 3MV to 13MV Ref.)

Capsule / Pole / Nomenclature	9		13		
	#1 Chan.	#2 Chan.	#1 Chan.	#2 Chan.	
Zero Scale (-3MV)	1	1			
Full Scale (13MV)	2	2			
Ref. Junction Temp $60^{\circ}F$ to $100^{\circ}F$	3	3			
Ref. Junction Temp $70^{\circ}F$ to $90^{\circ}F$	4	4			
T/M "A" Transmitter Z112					
UHF Power Amp. Z106.5	5	5	5	5	
Near Batt. Z105					
"S" Band Beacon Z107.5	6	6			
Envir. Area Z117.5					
H.F. Voice Transmitter			6	6	
Cabin Air Temp Z101.5	7	7			
"C" Band Beacon			7	7	
Cabin Air Temp Z145.5	8	8	8	8	
Heat Exchanger Outlet	9	9	9	9	
Heat Exchanger Inlet	10	10	10	10	
H_2O_2 Line, Conical Sect. (Auto)	11	11	11	11	
H_2O_2 Line, Conical Sect. (man)	12	12	12	12	
Solenoid Valve 24" Z170.5	13	13	13	13	

CONFIDENTIAL

Table 13-3. Special Instrumentation Parameters Commutator Point Assignments (Low Level - 3MV to 13MV Ref.) (Cont'd.)

Capsule	9		13		
Pole	#1	#2	#1	#2	
Nomenclature	Chan.	Chan.	Chan.	Chan.	
H_2O_2 Line to 24" Chamber	14	14	14	14	
H_2O_2 Tank (Man)	15	15	15	15	
H_2O_2 Tank (Auto)	16	16	16	16	
Heat Shield (Blkh'd cap)	17	17	17	17	
L/O Auto System Roll Solenoid Valve	18	18	18	18	
L/O Auto System Roll H_2O_2 Line	19	19	19	19	
Recovery Comp. (Inner Skin)	20	20	20	20	
Inner Skin Below Reaction Control Jets	21	21	21	21	
Recovery Comp (Int. Structure)	22	22	22	22	
Recovery Comp (Inner Skin)	23	23	23	23	
Ablation Shield (inbd)	24	24	24	24	
Ablation Shield (inbd)	25	25	25	25	
Parachute Comp. Z179	26	26	26	26	
Parachute Comp. Z179	27	27	27	27	
Parachute Comp. (Outer Skin) Ty	28	28	28	28	
Parachute Comp. (Outer Skin) Ty					
Emerg Egress Hatch (Outer Edge)	29	29	29	29	
Parachute Comp (Outer Skin) Lx	30	30	30	30	

Table 13-3. Special Instrumentation Parameters Commutator Point Assignments (Low Level - 3MV to 13MV Ref.) (Cont'd.)

Capsule	9		13		
Pole	#1	#2	#1	#2	
Nomenclature	Chan.	Chan.	Chan.	Chan.	
Parachute Comp (Outer Skin) Lx	69	69			
Emerg Egress Hatch (Outer Edge)	31	31	31	31	
Conical Section Sides Outer Skin					
Z154.5 Ty	32	32	32	32	
Z154.5 By	33	33	33	33	
Z154.5 Lx	34	34	34	34	
Z126.5 Ty	35	35			
Z117.0 Ty			35	35	
Emerg Egress (Percussion Ignitor)	36	36	36	36	
Conical Section Sides Outer Skin					
Z126.5 By	37	37	37	37	
Z126.5 By	38	38	38	38	
Conical Section Sides Outer Skin					
Z107. Ty	39	39	39	39	
Z107 By	40	40	40	40	
Z107 Lx	41	41	41	41	
Z107 Lx	42	42	42	42	
Tower to Capsule Retaining Ring (Top)	43	43	43	43	
Tower to Capsule Retaining Ring (Bottom)	44	44	44	44	
Tower to Capsule Retaining Ring (Bottom)	45	45	45	45	
Window Outside of Inner Pane	46	46	46	46	
Ablation Shield					
Mid.25 Glass Fiber	47	47	47	47	
Mid.25 Glass Fiber	48	48	48	48	

Table 13-3. Special Instrumentation Parameters Commutator Point Assignments (Low Level - 3MV to 13MV Ref.) (Cont'd.)

Capsule / Pole / Nomenclature	9 #1 Chan.	9 #2 Chan.	13 #1 Chan.	13 #2 Chan.	
Inbd Surface of Glass	49	49	49	49	
Inbd Surface of Glass	50	50	50	50	
Hat Sect. (Bottom) #12 Str.	51	51	51	51	
Hat Sect. (Bottom) #12 Str.	52	52	52	52	
R.H. Console Z126.5					
Hat Sect. (Side) #12 Str.	53	53			
T/M Xmitter Pwr Supply			53	53	
Hat Sect. (Top) #12 Str.	54	54	54	54	
Between C&S Band Beacons					
Hat Sect. (Bottom) #24 Str.	55	55	55	55	
Hat Sect. (Bottom) #24 Str.	56	56	56	56	
Transmitter Equipment					
Hat Sect. (Side) #24 Str.	57	57			
Hear Calibrator					
H_2O Tank			57	57	
Hat Sect. (Top) #24 Str.	58	58	58	58	
Near Inverters					
Left Side Window (Bolt)	59	59	59	59	

Table 13-3. Special Instrumentation Parameters Commutator Point Assignments (Low Level - 3MV to 13MV Ref.) (Cont'd.)

Capsule / Pole / Nomenclature	9		13		
	#1 Chan.	#2 Chan.	#1 Chan.	#2 Chan.	
Left Side Window (Inner Pane)	60	60	60	60	
Reaction Control Thrust Chamber					
Auto 24#	61	61	61	61	
Auto 1#	62	62	62	62	
Man 24#	63	63	63	63	
L/O Auto System Roll Catalyst Bed L.H.	64	64	64	64	
L/O Auto System Roll Catalyst Bed L.H.	65	65	65	65	
Heat Shield Attaching Bolts	66	66	66	66	
Horizon Scanner (Pitch)					
Horizon Scanner (Roll)	67	67	70	70	
Ant. Comp. (Outer Skin)			67	67	
Ant. Comp. (Inner Skin)	68	68			
	70	70			
Ant. Comp. (Outer Skin)	71	71	69	69	
Drogue Chute Can			68	68	
Parachute Comp. (Outer Skin) Lx			71	71	
Ant. Comp. (Inner Skin)					
Ant. Comp. (Outer Surface)	72	72	72	72	
Retro Rocket Package					
Z88 By XO	73	73	73	73	
Z88 By XR	74	74	74	74	
Z88 By XL	75	75	75	75	
Retro Rocket (Right)	76	76	76	76	
Retro Rocket (Bottom)	77	77	77	77	

Table 13-3. Special Instrumentation Parameters Commutator Point Assignments (Low Level - 3 MV to 13MV Ref.) (Cont'd.)

Nomenclature / Capsule / Pole	9 #1 Chan.	9 #2 Chan.	13 #1 Chan.	13 #2 Chan.	
Retro Rocket (Exp.Bolt)	78	78	78	78	
Adapter Sides Outer Skin					
Z79.5 LX	79	79	79	79	
Z79.5 By	80	80	80	80	
Z79.5 Ty	81	81	81	81	
Cap. to Adapter Retaining Ring	82	82	82	82	
Adapter Retaining Ring Cover	83	83	83	83	
Cap. to Adapter Explosive Bolt	84	84	84	84	
Escape Tower Z257	85	85	85	85	
Escape Tower (Left Leg)	86	86	86	86	
Pylon Explosive Bolt	87	87	87	87	
Stability Wedge	88	88	88	88	

13-111. Astronaut Observer Camera

The mechanism of the Astronaut observer camera is the same as that of the instrument panel observer camera.

13-112. TEST CONFIGURATION CAPSULES

13-113. TEST CONFIGURATION CAPSULE NO. 8

13-114. System Description

Instrumentation on Capsule No. 8 is similar to the Specification Compliance Capsule (Refer to Paragraph 13-1) except that Capsule No. 8 is intended for an unmanned (orbital) mission and therefore data pertaining to the Astronaut does not apply. Major components installed are shown on Figure 13-5.

13-115. System Operation

Instrumentation on Capsule No. 8 is similar to the Specification Compliance Capsule except is unmanned and operation is either automatic or ground controlled.

13-116. Monitoring Instrumentation

Monitoring instrumentation is the same as the Specification Compliance Capsule (Refer to Paragraphs 13-3 through 13-58) except as noted in Paragraph 13-117 through 13-136. Figure 13-6 shows the various parameters monitored while Table 13-2 lists the commutator point assignments for each parameter.

13-117. Standby Battery

The standby batteries, ON, signal comes from the secondary bus relay No. 2. This relay energizes if the STANDBY BATTERY switch is in AUTO position and main bus voltage is below 18 volts. With the relay energized, 24 volts d-c (nominal) is applied to an attenuator in package C. Attenuator output (2.8 volts d-c nominal) is applied to the commutators.

13-118. Environmental Control System

Environmental Control System instrumentation on Capsule No. 8 is the same as the Specification Compliance Capsule (Refer to Paragraphs 13-16 through 13-22) except that the emergency oxygen supply and O_2 partial pressure is not monitored.

13-119. Reaction Control System

Reaction Control System instrumentation on Capsule No. 8 is the same as the Specification Compliance Capsule (Refer to Paragraph 13-23) except that the hand control positions are not monitored.

13-120. Acceleration

Capsule acceleration instrumentation consists of circuitry which monitors acceleration along three mutually perpendicular axes. The launch and re-entry signal range is utilized throughout the flight. (Refer to Paragraph 13-30.)

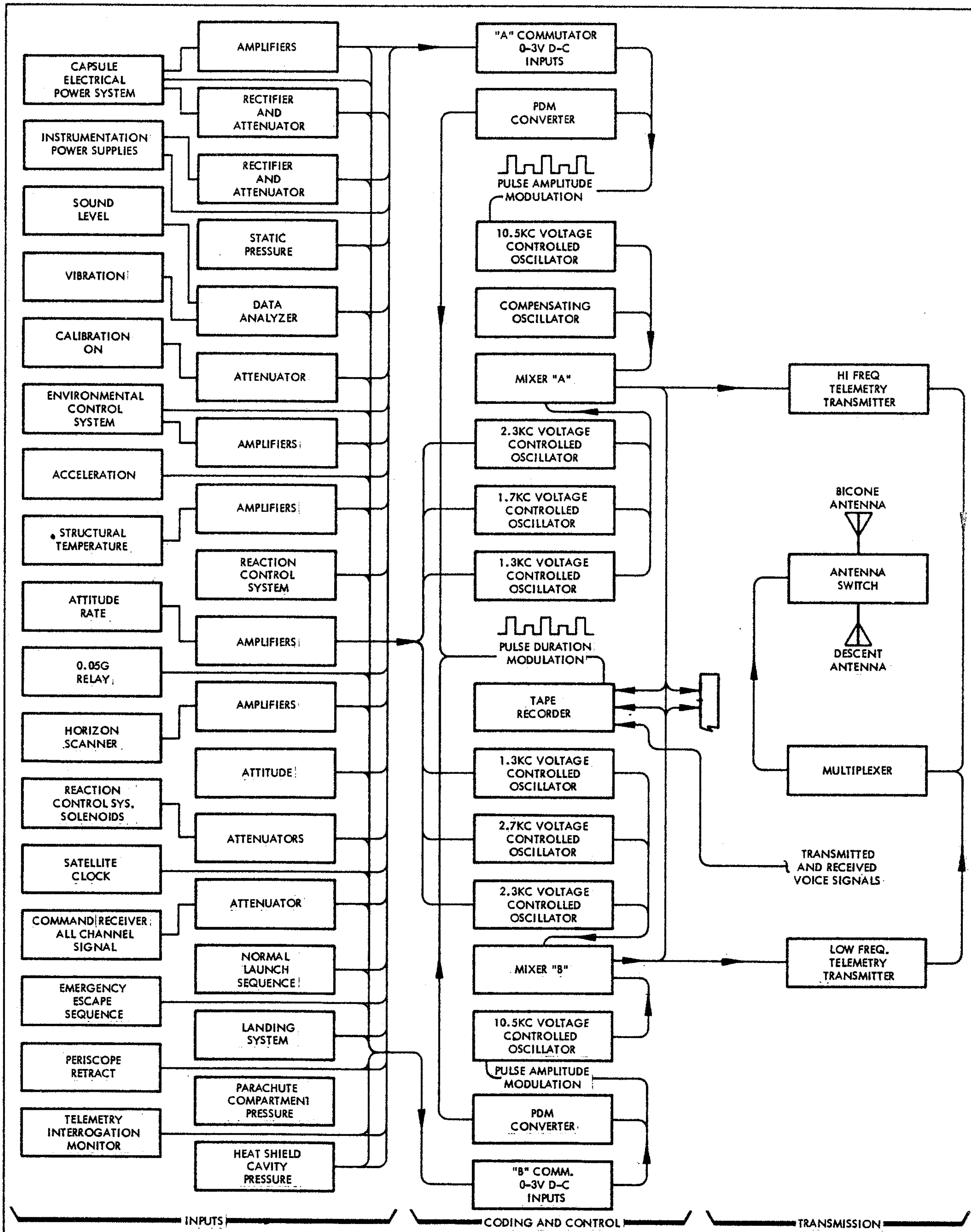


FIGURE 13-6 MONITORING INSTRUMENTATION BLOCK DIAGRAM-CAPSULE 8

PM45-199A

13-121. Structural Temperature

Structural temperature instrumentation is similar to the Specification Compliance Capsule. (Refer to Paragraph 13-32 through 13-38.)

13-122. Attitude Rate

Attitude rate signals are not commutated in Capsule No. 8. These signals are applied to the voltage controlled subcarrier oscillators that are utilized for electrocardiograph signals in the specification compliance capsule. A 0 volt signal level represents a zero attitude rate. A -1.5 volt signal represents a decreasing rate of 6 degrees per second and a plus 1.5 volt signal represents an increasing rate of 6 degrees per second. Pitch rate is applied to the 2.3 Kc. oscillators. Roll rate is applied to the 1.7 Kc. oscillators. Yaw rate is applied to the 1.3 Kc. oscillators. Pitch and roll signals are routed through a biasing circuit to set up the proper center frequency signal level.

13-123. Parachute Compartment and Heat Shield Cavity

The parachute compartment pressure and the heat shield cavity pressure on Capsule No. 8 is instrumented and monitored on the HF and LF Commutators.

13-124. Landing System Sequence

Landing system sequence instrumentation on Capsule No. 8 is the same as that for the specification compliance capsule (refer to Paragraph 13-54) except circuitry is added to monitor the Retro Rocket Gone Relay #1, #2, and #3. This signal is obtained from relays in Retrograde Relay Box #2. These signals are monitored on the HF and LF Commutators. The Landing Bag and Astronaut's Abort Systems are not monitored on Capsule No. 8.

13-125. Instrumentation Control

The instrumentation system controls and programs (See Table 13-1) power to its own and other system equipment.

a. The earth and sky camera viewing from capsule window operates at 10

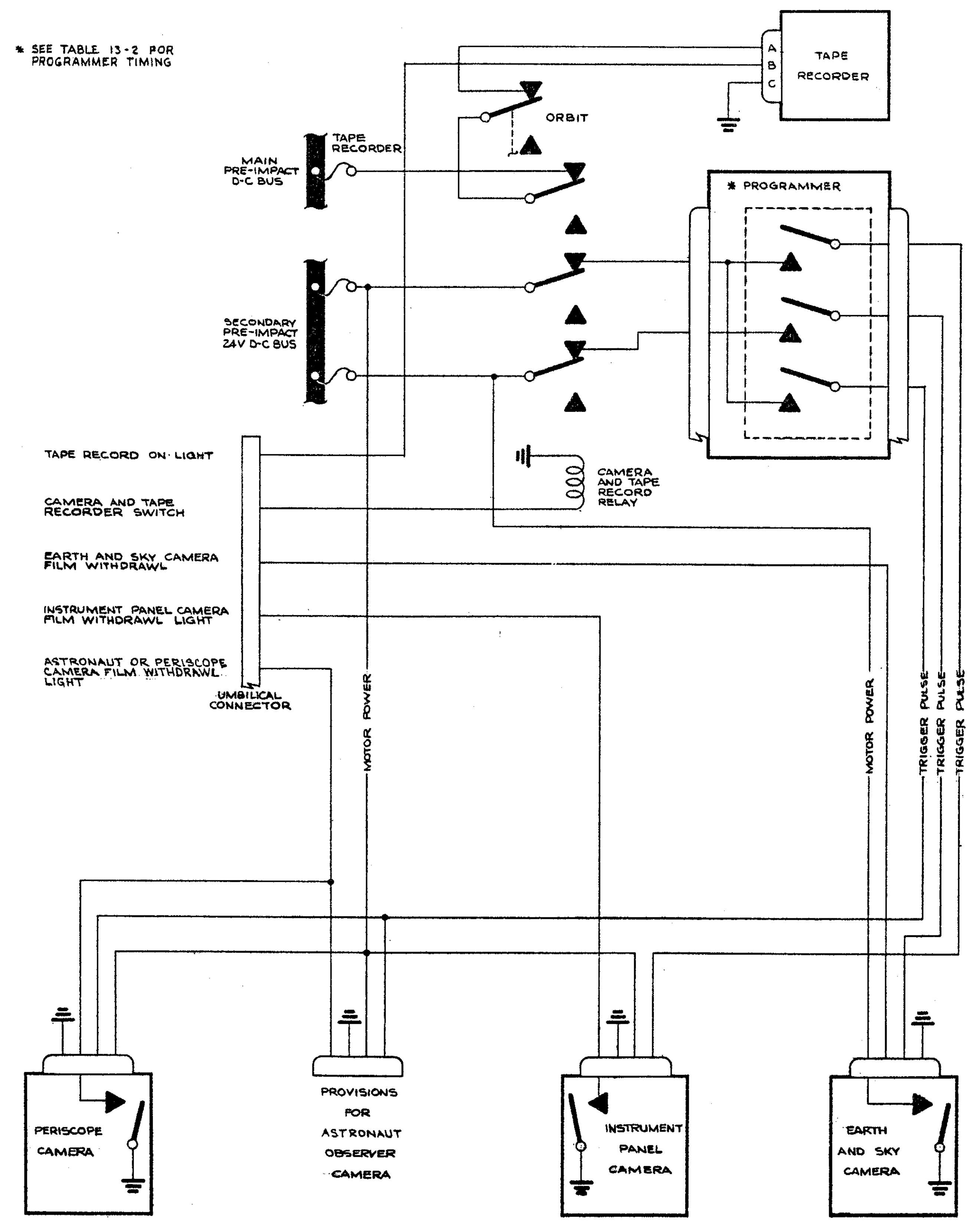


FIGURE 13-7 CAMERAS AND TAPE RECORDER CONTROL SCHEMATIC (CAPSULE NO. 8)

PM45-2008

frames per minute throughout the mission.

b. The periscope camera operates at 180 frames per minute throughout mission.

c. The instrument panel camera operates at 360 frames per minute during the mission.

d. Calibration voltages; R-calibrate for percent full scale readings and Z-calibrate for zero readings, are supplied from the block house before the umbilical is dropped, just prior to launch.

13-126. Recording Instrumentation

Recording instrumentation consists of a tape recorder and three cameras. The Astronaut observer camera is omitted from Capsule No. 8 and a periscope camera is installed. (See Figure 13-7.)

13-127. Tape Recorder

The tape recorder used on Capsule No. 8 is the same as the recorder used on the Specification Compliance Capsule (Refer to Paragraph 13-64), except the tape speed is 151 inches P/S. Also a Playback Tape Recorder to simulate the Astronaut's voice (See Section XI and Table 13-1) is installed.

13-128. Cameras

Capsule No. 8, being an unmanned vehicle, does not use an Astronaut observer camera. The usual Instrument Panel Camera is installed, as well as an Earth and Sky Camera and a Periscope Camera. (See Figure 13-5). Programming is received from the capsule programmer.

13-129. Special Instrumentation

A special instrumentation package is used in Capsule No. 8. The package consists of fuse blocks, special instrumentation relays, five track tape recorder and a nine channel amplifier case with associated power supply. Vibration measurements are taken from various points on the capsule, amplified and applied to separate tracks on the package tape recorder or to the capsule tape recorder. A total of nine tracks are recorded as follows:

Pallet Tape Recorder	Capsule Tape Recorder
Track 2 Z123 Ring Longitudinal	Track 2 Package "B" Noise Level
Track 3 Web at LX12	Track 4 Z123 Ring Radial
Track 4 Instrument Panel	Track 6 Shingle Strain Gage
Track 6 Z123 Ring Tangential	Track 7 Escape Tower
Track 7 Parachute Compartment	

13-130. System Units

The system units used on Capsule No. 8 are the same as the Specification Compliance Capsule except as noted in the following paragraphs. (Refer to Paragraphs 13-68 and 13-69.)

a. Main and Reserve Oxygen Pressure Potentiometers are not instrumented
b. Respiration rate and Depth Potentiometers are not monitored
c. Control Stick Potentiometers are not monitored
d. Body Temperature Transducers are not used
e. Electrocardiogram Pickups are not used
f. Tape Recorder is the same as specification compliance capsule. (Refer to Paragraph 13-82.)

13-131. Sound Level and Vibration Transducers

A microphone and amplifier are located in the B package for sound level pickup. A piezo-electric/diaphragm type microphone is used to pick up a pressure level of 100 to 140 db with a frequency range of 37 to 9600 cps. The variable gain, transistorized amplifier consists of an impedance matching stage, filter network, buffer stage and final amplifier. Amplifier output, 3 volts RMS, is used with a data analyzer. A piezo-electric crystal is used as a vibration pickup, measuring a frequency range of 10 to 2000 cps. The transducer is used in conjunction with vibration amplifier.

13-132. Vibration Amplifier and Data Analyzer

A transistorized amplifier is used to increase the output of the vibration transducer to a level compatible with an accoustical and vibration analyzer.

13-133. Programmer

The programmer contains switch contacts which operate control circuits for specific intervals of time. The unit for Capsule No. 8 consists of one section of wafer contacts. When power is applied to the programmer the electronic controlled timers continuously operate the following wafer contacts.

Wafer Section	Duration	Rate	Function
1	30 Seconds	1 Per 30 Min.	Water Extractor
2	110 Milliseconds	6 Per Second	Instr. Panel Camera
3	90 Milliseconds	10 Per Minute	Earth & Sky Camera
4	110 Milliseconds	3 Per Second	Periscope Camera

13-134. Instrumentation Package "C"

The horizon scanner output amplifier card in package "C" provides a bias voltage to keep the horizon scanner pitch and roll signals within limits compatible with other system components. Calibrate control relays are installed on the card. Roll ignore and pitch ignore signals are jumpered through the card. The Horizon Scanners operate continuously from launch to re-entry.

13-135. Instrumentation Package "A"

The instrumentation package "A" is the same as the Specification Compliance Capsule except for the removal of the body temperature amplifier card.

13-136. Instrumentation Package "B"

The components used in package "B" of Capsule No. 8 are the same as in the package "D" in specification compliance capsule except for the following units. (Refer to Paragraph 13-102.)

a. Attitude Change Rate Filter and Calibrate Cards

Attitude change rate filter and calibrate cards replace the electrocardiograph amplifier cards. Three attitude change rate cards are used. They are for pitch, roll and yaw parameters. The cards associated with pitch and roll rate provide for application of calibrate signals to these channels. The yaw rate card provides this function and also contains a bias battery to set up center frequency on the voltage controlled oscillator when yaw rate equals zero degrees per second.

b. Voltage Controlled Oscillator Cards

The oscillator cards used in Capsule No. 8 are similar to those used in the specification compliance capsule. (Refer to Paragraph 13-107.) However, attitude rate signals are applied to the oscillators instead of aeromedical signals. Oscillator functions and frequencies are indicated in the following list.

HF Commutator

HF Commutator output is applied to the 10.5 Kc oscillator.

Yaw Rate is applied to the 1.3 Kc oscillator.

Roll Rate is applied to the 1.7 Kc oscillator.

Pitch Rate is applied to the 2.3 Kc oscillator.

Compensating Oscillator frequency is 3.125 Kc.

LF Commutator

LF Commutator output is applied to the 10.5 Kc oscillator.

Yaw Rate is applied to the 1.3 Kc oscillator.

Roll Rate is applied to the 1.7 Kc oscillator.

Pitch Rate is applied to the 2.3 Kc oscillator.

13-137. TEST CONFIGURATION CAPSULE NO. 9

13-138. System Description

The instrumentation system on Capsule No. 9 is similar to the Specification Compliance Capsule (Refer to Paragraph 13-1) except that the capsule will be

McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI
DATE 1 NOVEMBER 1961
REVISED
REVISED

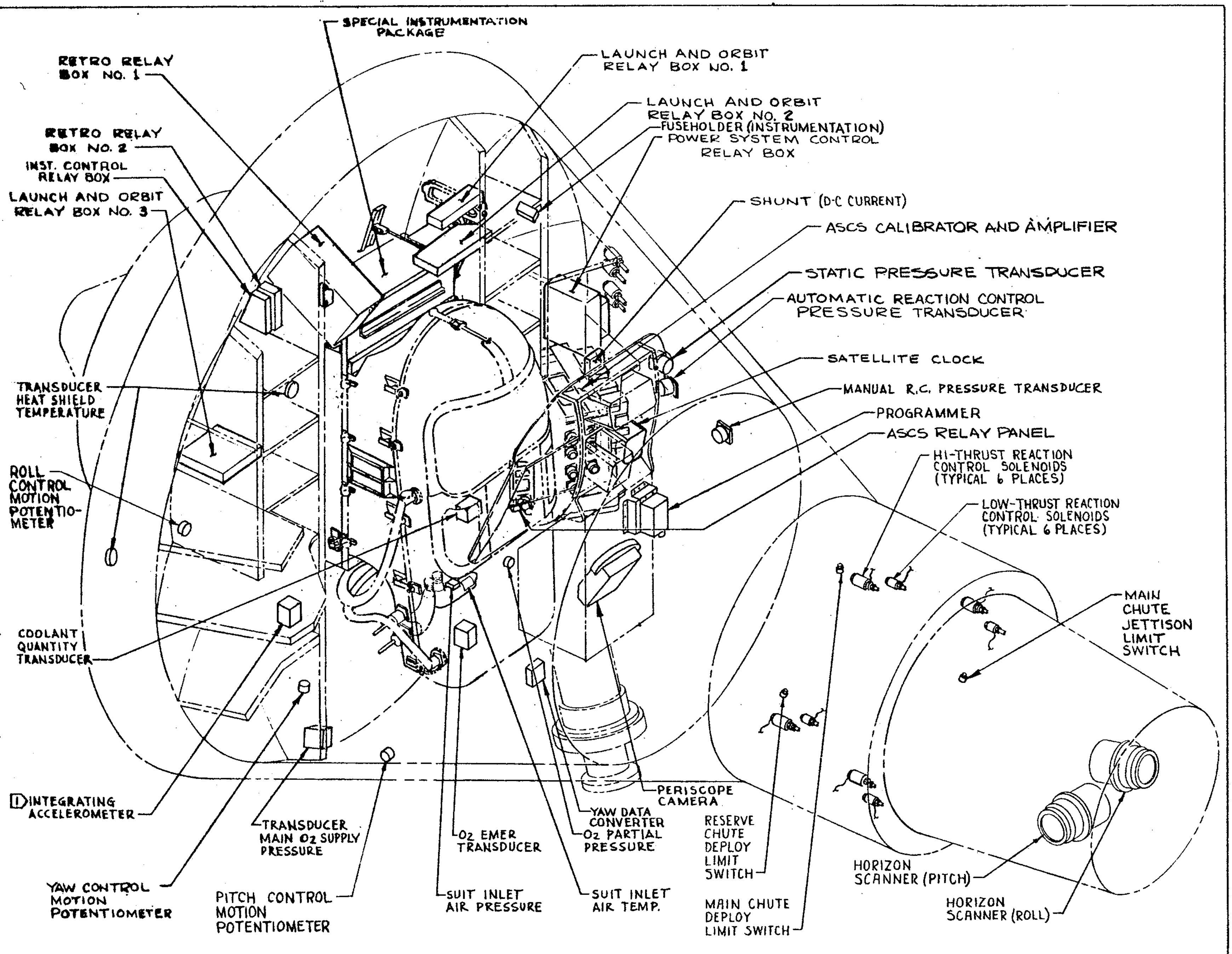


FIGURE 13-8 INSTRUMENTATION SYSTEM - CAPSULE 9 (SHEET 1 of 2)

FM45-241A-1

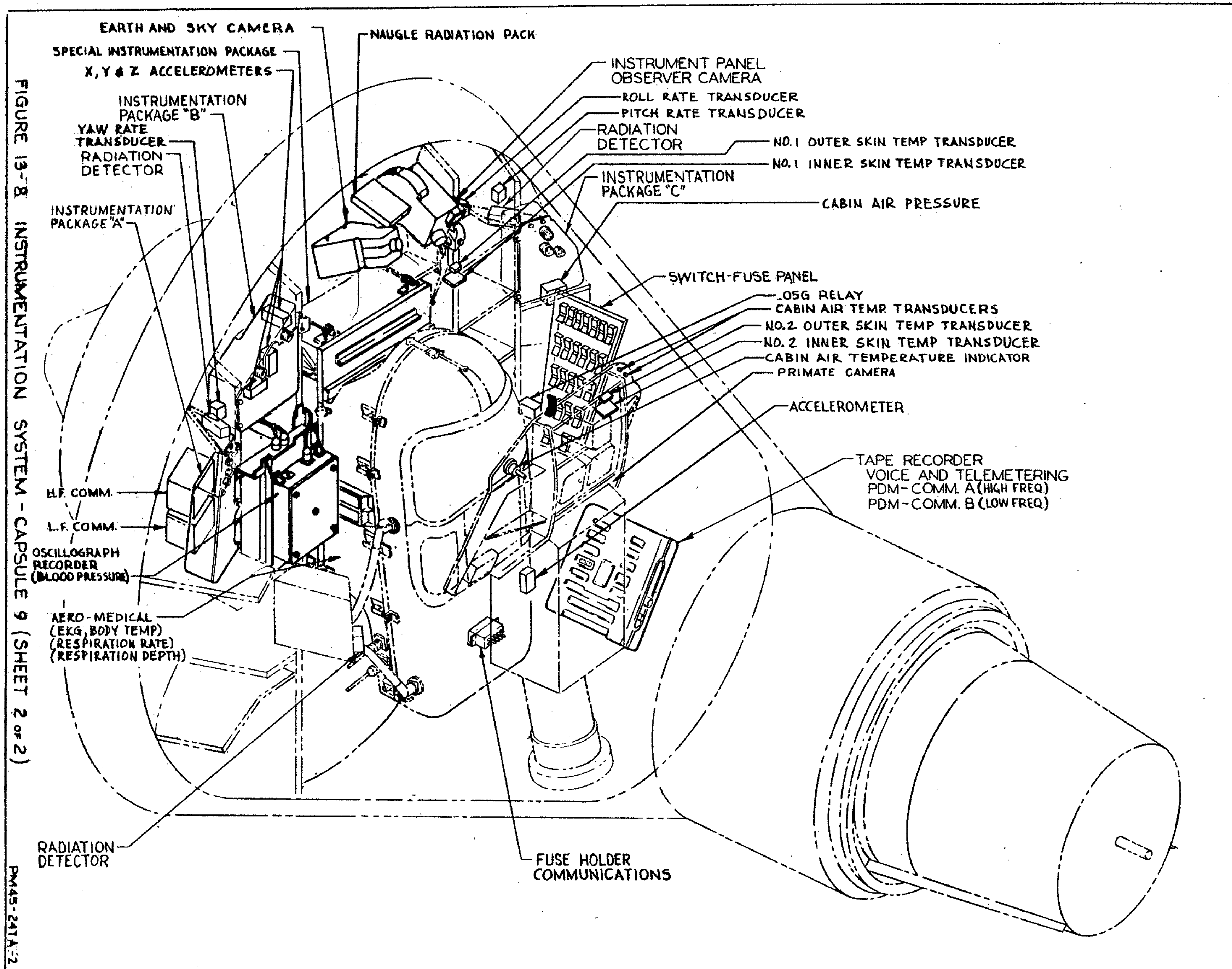


FIGURE 13-8 INSTRUMENTATION SYSTEM - CAPSULE 9 (SHEET 2 of 2)

unmanned and a special instrumentation pallet and primate couch replaces the Astronaut's couch. Major components installed are shown on Figure 13-8.

13-139. Monitoring Instrumentation

Monitoring Instrumentation differs from the Specification Compliance Capsule in that Capsule No. 9 is instrumented for primate occupancy. Figure 13-9 shows the parameters in block diagram form while Table 13-2 lists the commutator point assignments for all telemetered instrumentation. Deviations from the Specification Compliance Capsule are explained in Paragraphs 13-140 through 13-157.)

13-140. Standby Battery

In Capsule No. 9 the standby battery power is connected directly to the main d-c bus, in parallel with the main batteries. The standby d-c auto light or automatic switching of the standby to the main bus is not used.

13-141. Special Instrumentation Pallet

The Special Instrumentation Pallet is installed in place of the Astronaut's Couch. The pallet contains an array of circuits for instrumenting the various parameters as listed on Table 13-3. Location of the sensors are indicated on Figure 13-11 and the point assignments for each parameter are listed on Table 13-3. The values measured by each sensor is encoded by the multicoder and recorded on a tape recorder. Power for the pallet is obtained from the 150 volt-ampere inverter and controlled by a multicoder "ON" - "OFF" switch.

13-142. Blood Pressure Oscillograph

The oscillograph-tape recorder, which records the venous and arterial blood pressure of the chimpanzee is mounted beside the Special Instrumentation Pallet. The oscillograph is powered by its own, self contained, wet-cell battery. The power is controlled by an external ON-OFF switch. A transducer is attached to the Solar-Plexis of the chimp, which converts blood pressure values to electrical signals. These signals are routed through an amplifier in Instrument Package "A",

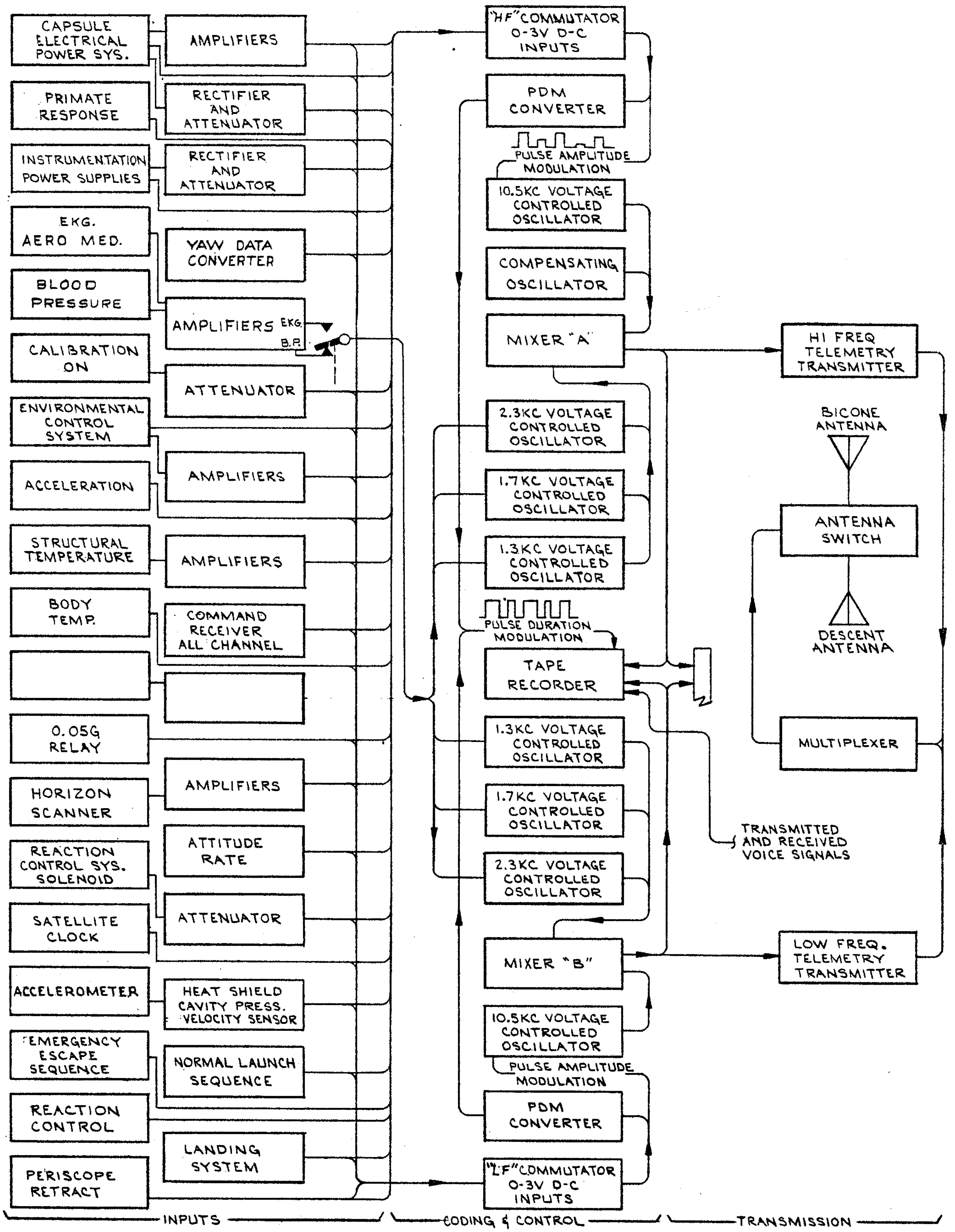
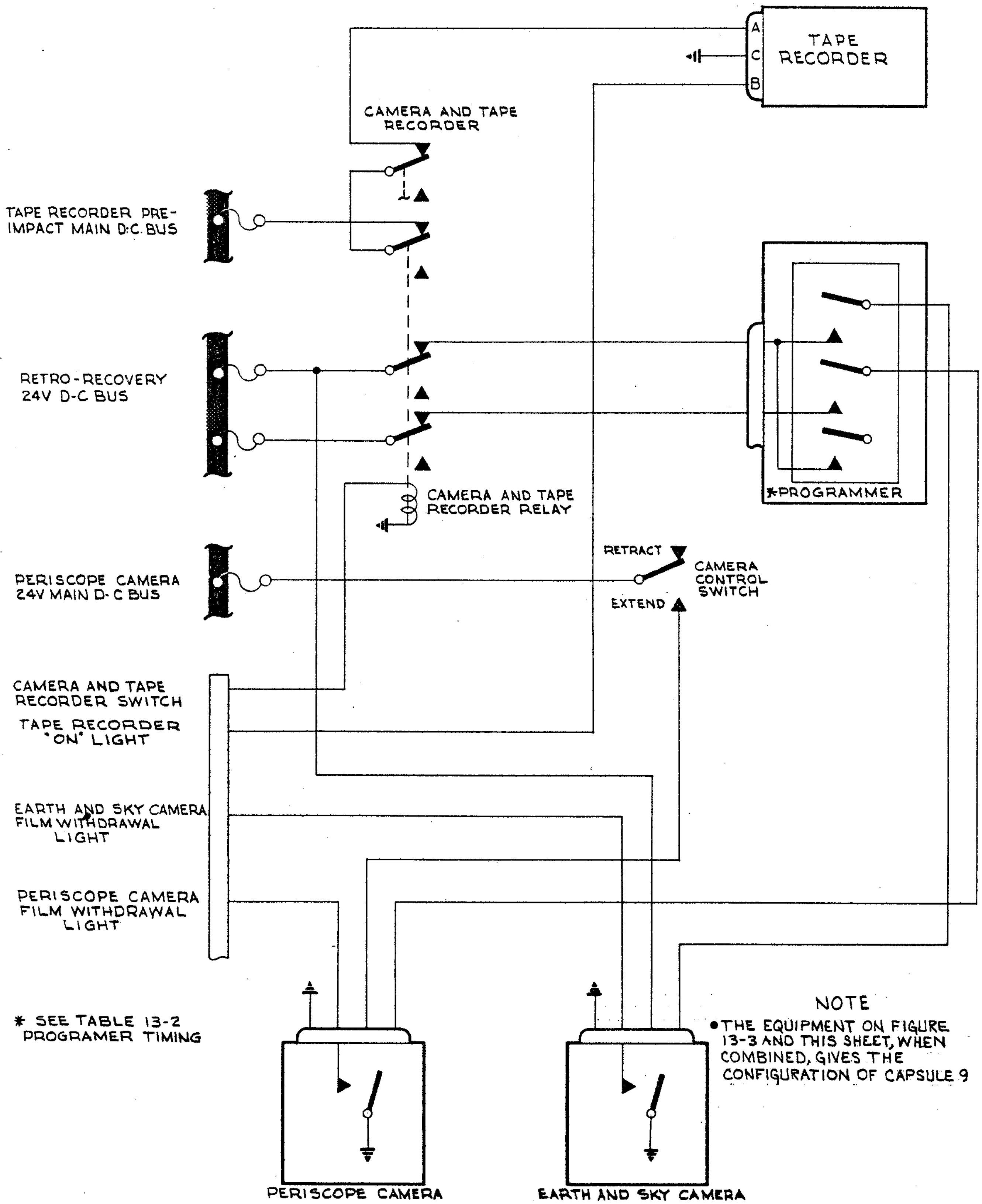


FIGURE 13-5 MONITORING INSTRUMENTATION BLOCK DIAGRAM - CAPSULE 9

PM45-194C



NOTE
- THE EQUIPMENT ON FIGURE 13-3 AND THIS SHEET, WHEN COMBINED, GIVES THE CONFIGURATION OF CAPSULE 9

FIGURE 13-10 CAMERAS AND TAPE RECORDER CONTROL CIRCUIT (CAPSULE #9)

PM 45-245B

ITEM	DESCRIPTION	LOCATION		
1	RETRO ROCKET PACKAGE (RETRO ROCKET - RIGHT)		RX	TY
2	ADAPTER SIDES - OUTER SKIN	Z79.5		TY
3	RETRO ROCKET PACKAGE	Z88.0	RX	BY
4	RETRO ROCKET EXPLOSIVE BOLT	Z81.6	XO	YO
5	ABLATION SHIELD - BETWEEN .06 AND .2 FIBERGLASS		RX33	TY3
6	RETRO ROCKET PACKAGE	Z88.0	XO	TY
7	HEAT SHIELD ATTACH POINT	Z104.5	XO	TY
8	CAPSULE TO ADAPTER EXPLOSIVE BOLT	Z103.0	XO	TY
9	H_2O_2 TANK - AUTOMATIC	Z104.5	XO	
10	CONICAL SECTION SIDES - OUTER SKIN	Z107.0		TY
11	ADAPTER SIDES - OUTER SKIN	Z79.5	LX	
12	ABLATION SHIELD - BETWEEN .06 & .2 FIBERGLASS		LX1	TY2
13	CABIN AIR TEMPERATURE	Z101.5	LX18	YO
14	HAT SECTION - #24 STRINGER, BOTTOM	Z127.0		TY
15	CONICAL SECTION SIDES - OUTER SKIN	Z126.5	XO	TY
16	HAT SECTION - #24 STRINGER, TOP	Z127.0	XO	TY
17	HAT SECTION - #24 STRINGER, SIDE	Z127.0		TY
18	HAT SECTION - #24 STRINGER, BOTTOM (7 1/2")	Z127.0		TY
19	CONICAL SECTION SIDES - OUTER SKIN	Z107.0	LX	
20	WINDOW - BOLT			
21	WINDOW - INSIDE OF OUTER PANE			
22	WINDOW - INNER PANE			
23	I/O AUTO SYSTEM ROLL - H_2O_2 LINE	Z108.8	LX	BY1
24	I/O AUTO SYSTEM ROLL - SOLENOID VALVE	Z110.2	LX	BY1
25	I/O AUTO SYSTEM ROLL-CATALYST BED (L.H.)	Z114.0	LX	BY1
26	H_2O_2 LINE CONICAL SECTION - AUTOMATIC	Z126.5		
27	CONICAL SECTION SIDES - OUTER SKIN	Z154.5		TY
28	CONICAL SECTION SIDES - OUTER SKIN	Z154.5	LX	
29	SOLENOID VALVE TOP 24 LB.	Z170.5	XO	TY
30	REACTION CONTROL THRUST CHAMBER - TOP (AUTO #24)	Z178.0	XO	TY
31	PARACHUTE COMPARTMENT - OUTER SKIN	Z178.0	XO	TY
32	REACTION CONTROL THRUST CHAMBER - TOP (AUTO #1)	Z179.0	LX	TY
33	TOWER TO CAPSULE RETAINING RING (TOP)	Z184.6	XO	TY
34	PARACHUTE COMPARTMENT - OUTER SKIN	Z178.0	LX	YO
35	RECOVERY COMPARTMENT INTERNAL STRUCTURE	Z184.6	LX6	BY12
36	ANTENNA COMPARTMENT INNER SKIN	Z191	XO	BY
37	HORIZON SCANNER (ROLL)			
38	ANTENNA COMPARTMENT LID	Z208.7	XO	BY2.5
39	ANTENNA COMPARTMENT OUTER SKIN (BOTTOM)	Z191	XO	BY
40	RECOVERY COMPARTMENT INNER SKIN	Z179.0	RX5	BY13
41	PYLON EXPLOSIVE BOLT	Z184.6	RX85	BY
42	PYLON EXPLOSIVE BOLT COVER	Z184.6	XO	BY
43	TOWER TO CAPSULE RETAINING RING (BOTTOM)	Z185.7	LX.5	BY
44	TOWER TO CAPSULE RETAINING RING - BOTTOM	Z184.6	XO	BY
45	PARACHUTE COMPARTMENT SIDE	Z178.0	XO	BY
46	INNER SKIN BENEATH JET SUPPORT	Z177.0	LX2	TY13
47	RECOVERY COMPARTMENT INNER SKIN	Z177.0	LX	TY
48	H_2O_2 LINE - TOP 24 LB.	Z168.5	XO	TY
49	CONICAL SECTION SIDES - OUTER SKIN	Z154.0		BY
50	CABIN AIR TEMPERATURE	Z145.5	XO	YO
51	HAT SECTION BOTTOM - 7 1/2" #12 STRINGER	Z127.0		BY
52	HAT SECTION BOTTOM - #12 STRINGER	Z127.0		BY
53	HAT SECTION SIDE - #12 STRINGER	Z127.0		BY
54	HAT SECTION TOP - #12 STRINGER	Z127.0		BY
55	CONICAL SECTION SIDES - OUTER SKIN	Z126	XO	BY
56	HEAT EXCHANGE (OUTLET)			
57	HEAT EXCHANGER (INLET)			
58	CONICAL SECTION SIDES - OUTER SKIN	Z107.0		BY
59	ADAPTER RETAINING RING	Z104.5	XO	BY
60	ADAPTER RETAINING RING COVER	Z104.5	XO	BY
61	ABLATION SHIELD - SHIELD INBOARD SURFACE		XO	TY2
62	ABLATION SHIELD BETWEEN .2 FIBERGLASS AND HONEYCOMB		LX1	TY2
63	RETRO ROCKET PACKAGE	Z88.0	LX	BY
64	RETRO ROCKET PACKAGE (RETRO ROCKET - BOTTOM)		XO	BY
65	ADAPTER SIDES - OUTER SKIN	Z79.5		BY
66	ABLATION SHIELD - SHIELD INBOARD SURFACE	Z79.5		BY
67	HEAT SHIELD - BULKHEAD CAP		RX33	TY2
68	ESCAPE TOWER	Z257.0	XO	TY1
69	ESCAPE TOWER	Z109.5	LX	BY
70	ABLATION SHIELD BETWEEN .2 FIBERGLASS AND HONEYCOMB		RX33	TY3
71	REACTION CONTROL THRUST CHAMBER - TOP (MANUAL #24)	Z178.0	LX	TY
72	H_2O_2 TANK - MANUAL	Z104.5	XO	
73	H_2O_2 LINE CONICAL SECTION - MANUAL	Z126.5		
74	EMERGENCY EGRESS HATCH - OUTER EDGE	Z123.0		
75	EMERGENCY EGRESS HATCH - OUTER EDGE	Z146.0		
76	EMERGENCY EGRESS HATCH - PERCUSSION IGNITER, TOP	Z126.5		
77	UHF POWER TRANSMITTER	Z106.5		
78	S BAND BEACON	Z107.5		
79	EGRESS HATCH	Z124.25		
80	EGRESS HATCH	Z147.25		
81	TM TRANSMITTER			
82	TM TRANSMITTER			
83	INVERTER			
84	INVERTER			

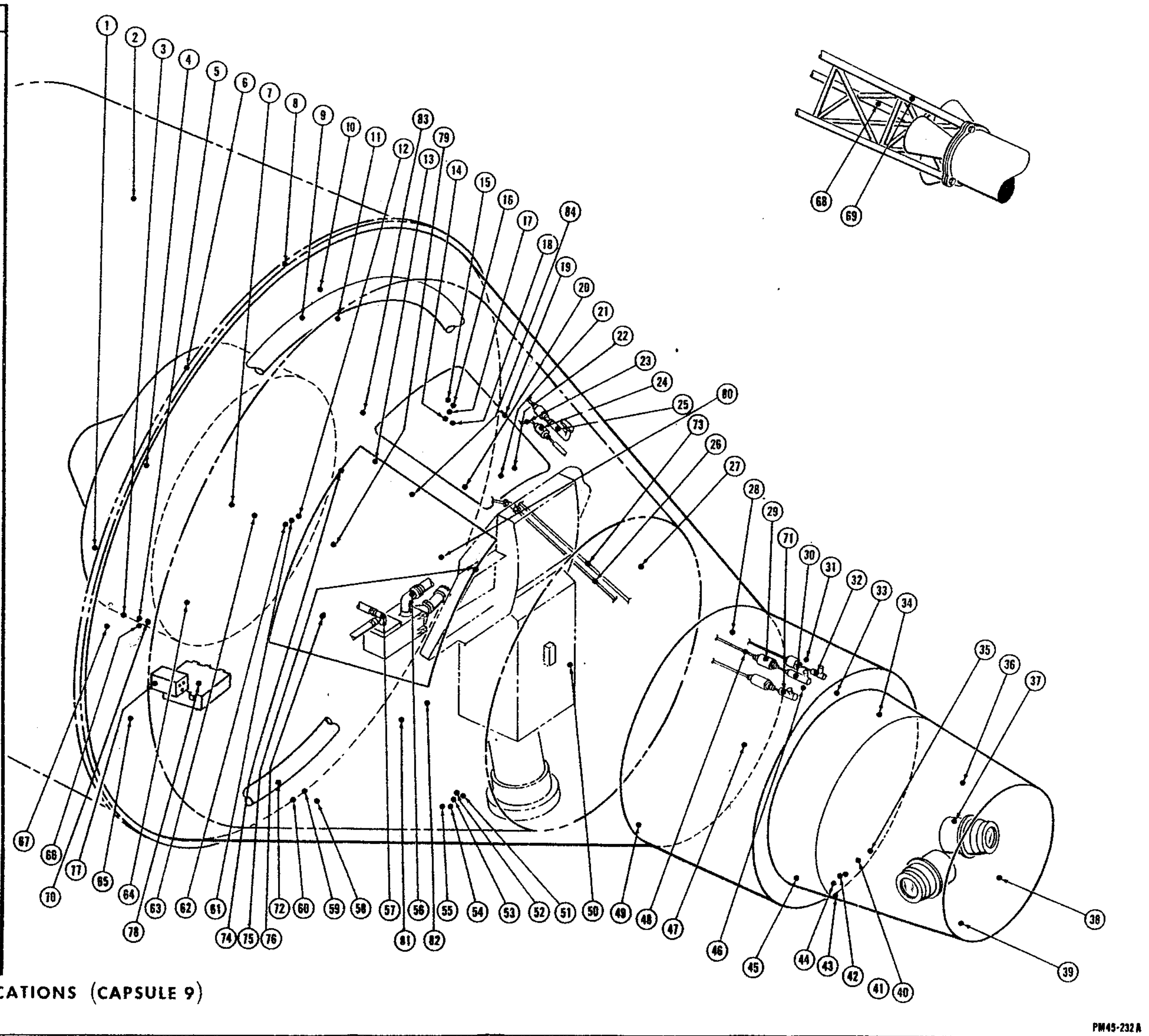


FIGURE 13-11 THERMOCOUPLE LOCATIONS (CAPSULE 9)

where the signal strength is sufficiently increased to be recorded on the oscillograph. These signals are not telemetered to the ground.

13-143. Parachute Compartment and Heat Shield Cavity

The parachute compartment and heat shield cavity pressure is monitored on the HF and LF Commutators. The pressures are measured by transducers, the outputs of which are linear from 0 to 3 volts for a pressure range of 0-15 psia.

13-144. Inactive Parameters

The following circuits are not monitored on Capsule No. 9:

a. Control Stick Position

b. Abort Switch

c. Landing Bag

13-145. Yaw Data Converter

A Yaw Data Converter is installed on Capsule No. 9. The function of the converter is to provide calibrated conversion of the ASCS slaving, output signals to compatible input signals for the Telemetry Commutators. Two d-c signals are produced which are proportional to the "Roll to Yaw-Low Gain" and "Roll to Yaw-Hi Gain". Also a third d-c signal is produced which is proportional to the "Yaw Torquing" a-c signal of the ASCS calibrator, and is designated as the "Yaw Torquer" signal. Zero yaw attitude is represented by 1.75 volts output for the low-gain signal and 1.5 volts for the hi-gain signal. Meter ranges for all three signals is 0-3 volts d-c and represents yaw commands of -45 to 45 degrees for lo-gain, -10 to 10 degrees for hi-gain and -6.5 to 6.5 degree/minute slaving rate, for the yaw torquer signal. These signals are telemetered on both the HF and LF Commutators. The Yaw Data Converter is powered by 115V 400 cps a-c, 3.0 volts d-c and 23.5 volts d-c supplied from the capsule power circuits.

13-146. Horizon Scanners

The horizon scanners are instrumented on both HF and LF Commutators.

13-147. Retro Rocket Firing - Velocity Sensor

The velocity sensor is not instrumented, instead, each of the three Retro-Rocket firing signals are applied to the HF and LF Commutators.

13-148. Body Temperature

The chimp body temperature is monitored and applied to the HF and LF Commutators.

13-149. Command Receiver

The command receivers all channel signal is instrumented on Capsule No. 9.

13-150. Aeromedical

Aeromedical instrumentation on Capsule No. 9 is the same as that for the Specification Compliance Capsule (Refer to Paragraphs 13-39 through 13-43), except that since a primate is being used the scale factors for EKG and respiration data are different and only three EKG transducers are used on the primate.

13-151. Primate Instrumentation

The primate couch is mounted on the special instrumentation pallet and is instrumented to monitor the primate's reactions and response. Since Capsule No. 9 is assigned to a specific mission, the primate instrumentation is programmed differently than other primate test capsules. The primate Programmer consists of an electronic panel assembly and a liquid feeder. The instrument panel contains three display units, the left-hand unit consists of six symbols and a cyan blue disc display, the center unit has six symbols, a yellow disc and a white disc display and the right-hand unit has six symbols, a red disc and green disc display. Three switch levers are provided for primate actuation, with each switch closure recorded on a four digit counter mounted near the left switch lever. A pellet dispenser is mounted on the panel and will dispense, on command of a 28 volt pulse, reward pellets through a hole in the lower right-hand corner of the panel. A liquid dispenser is mounted in the vicinity of the right-hand side of the animal's head. It will dispense a drink of liquid when actuated by a 28 volt pulse and triggered by the animal's lips. Power is supplied for the primate's couch from the special instrumentation fuse block through the special instrumentation recorder relay. The animal's response during the various program sequences is recorded and telemetered as listed on Table 13-2. The programmed psychomotor presents the sequence of test functions the animal must perform and are as follows:

TEST	TIME
1. RS-CS - Regular and classified shock avoidance	15 min.
2. TO - Time Out	2 min.
3. DRL - Differential reinforcement of low rates	5 min.
4. TO - Time Out	2 min.
5. FR - Fixed ration reward	5 min.
6. TO - Time Out	5 min.
7. PRPM/NRPM Position and Negative reinforcement Perceptual monitoring	
(a) 18 Combinations of symbols	5 min.
(b) 18 Combinations of 1, -, X symbols	
8. TO - Time Out (Note: If the last 36 combinations are completed before the 5 minutes has elapsed the remaining time is out and the entire program starts over).	

A description of the tests in the sequence they occur and required telemetered data is as follows:

a. RS-CS (time 15 min.). The telemetered outputs are as follows:

(1) Program identification through indication of shock.

(2) Cumulative response of left lever.

(3) Cyan blue light on and duration.

(4) Cumulative response of right lever.

b. TO (Time 2 min.) No displays.

Telemetered outputs:

(1) Identification (zero input to TM)

(2) Cum. response of left lever

(3) Cum. response of center lever

(4) Cum. response of right lever

c. DRL (Time 5 min.)

Green light in right display unit is activated. If animal waits 20 seconds before pulling right hand lever, a green light appears beside the liquid feeder and a drink may be obtained. If R/H lever is pulled before 20 seconds time span, the animal must wait an additional 20 seconds for another opportunity for a drink.

Telemetered outputs:

(1) Program identification

(2) Cum. response left and center levers

(3) Liquid feeder actuation

(4) Cum. response right lever

d. TO (Time 2 min.) NO display.

e. FR (Time 5 min.)

Yellow light in center display unit is activated. If animal presses center lever 50 times, the pellet dispenser is actuated and he gets a pellet as a reward.

Telemetered outputs:

(1) Program identification

(2) Cum. response of left lever

(3) Cum. response of center lever

(4) Cum. response of right lever

f. TO (Time 2 min.)

g. PRPM/NRPM (1)
PRPM/NRPM (2) (time 5 min.)

NRPM mode of operation - If correct lever is pulled, 15 seconds of time-out results, lights are out. The lights then come on with new display and there is 20 seconds allowed for another decision. Correct lever sets beneath odd display. If no lever or wrong lever is pulled, shocks occur every five seconds after 20 second decision time, until correct answer is made.

PRPM mode of operation - The lever beneath the odd display provides a pellet reward. Depression of either of the other two levers results in no reward and provides 15 second time-out after which same display appears.

Telemetered outputs:

(1) Program identifier

(2) Cum. response of left lever

(3) Cum. response of center lever

(4) Cum. response of right lever

h. Ten minutes after impact the nipple on the liquid feeder is armed and the green light appears allowing the chimp to obtain a drink.

13-152. Instrumentation Control

Instrumentation Control Circuitry for Capsule No. 9 is similar to the Specification Compliance Capsule except for the programmer which provides controlled power (See Table 13-1) for the following circuits.

(a) The environmental control system water extractor is supplied a 30 second pulse every 30 minutes.

(b) The Instrument Camera is the same as in the Specification Compliance Capsule.

(c) The Earth and Sky Observer Camera is provided a 90 millisecond pulse, ten times per minute, during the entire flight.

(d) The Primate Observer Camera is programmed the same as in the Specification Compliance Capsule.

(e) The Periscope Camera is provided a 110 millisecond pulse, 30 times per second during re-entry and 1800 times per hour while in orbit. The camera is operable only when the periscope is extended.

(f) "R" & "Z" calibrate is the same as the Specification Compliance Capsule.

13-158. Recording Instrumentation

Capsule No. 9 Recording Instrumentation (See Figure 13-11) consists of a tape recorder and four cameras, the tape recorder, Instrument Camera and Astronaut Camera are the same as used in the Specification Compliance Capsule (See Paragraphs 13-65 and 13-66), except that the Astronaut Camera is adjusted to view the primate. A 70 millimeter Earth and Sky observer camera is mounted at the observation window. This camera is sighted to record a field of view through the window. The image of a timer is superimposed on one corner of each frame. The camera is supplied 24 volt power and pulsing voltage from the capsule power system. Each pulse operates the shutter, exposing one frame and transporting the film for the next exposure. Trigger pulses are applied to the camera at the rate of 10 per minute by the programmer. In addition, a periscope camera is used on Capsule No. 9. The camera is mounted inside the periscope, to view the earth as it would be seen through the periscope, by an observer inside the capsule. Power is applied to the camera, only when the periscope is extended. (See Figure 13-10.) Pulses for the camera are supplied from the capsule programmer. (See Table 13-1.)

13-154. System Units

System Units in Capsule No. 9 are the same as used on the Specification Compliance Capsule, (Refer to Paragraphs 13-68 through 13-81), except the units added in Paragraphs 13-155 thru 13-157.

13-155. Yaw Data Converter

The Yaw Data Converter is a small compact unit consisting of transformers, demodulators, relays and summing circuitry. The unit is mounted in the lower section of the capsule near the periscope. (See Figure 13-8.)

13-156. Periscope Camera

The Periscope Camera used on Capsule No. 9 is the same as the Instrument Camera except that the periscope camera is mounted inside the periscope. (Refer to Paragraph 13-110.)

13-157. Blood Pressure Oscillograph

The blood pressure oscillograph consists of a motor timer and tape recorder. The oscillograph also has a self-contained battery mounted with the recorder. The battery is vented in the same manner as the capsule's main batteries. The oscillograph operates at a speed of 8 inches per minute and is on continuous from the time the recorder's power switch is turned on, prior to launch, until it is turned off, after landing.

13-158. TEST CONFIGURATION CAPSULES NO. 10, 13 AND 16.

13-159. General

The Instrumentation on Capsules No. 10, 13 and 16 is the same as the Specification Compliance Capsule (Refer to Paragraphs 13-1 thru 13-110.) (See Table 13-2 for commutator point assignments.)